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A MICROPROCESSOR – BASED CONTROLLER FOR THE PLUGGING FACTOR MONITOR

May 1981
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The Yuma Desalting Test Facility was constructed by the Bureau of Reclamation to provide data to design the proposed Yuma Desalting Plant near Yuma, Ariz. This plant would reduce the salinity of Colorado River water delivered to Mexico. Instrumentation for the test facility includes a measuring device to monitor the plugging factor of the water at various points in the water pretreatment process. The plugging factor indicates the amount of organic and inorganic particulate matter which is suspended in the water. To automate the measurement process, a controller was needed for the measuring device. This report covers the maintenance and operation procedures for this controller. Hardware drawings of the system and flowcharts of the system software are included.

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May 1981

Power and Instrumentation Branch
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SI METRIC

UNITED STATES DEPARTMENT OF THE INTERIOR ★ BUREAU OF RECLAMATION

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In May of 1981, the Secretary of the Interior approved changing the Water and Power Resources Service back to its former name, the Bureau of Reclamation.

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ABBREVIATIONS AND SYMBOLS

a-c or a.c.	alternating current
A/D	analog-to-digital converter
ASCII	American Standard Code for Information Interchange
BCD	binary coded decimal
CMOS	complementary metal oxide semiconductor
CPU	central processing unit
D/A	digital-to-analog converter
d-c or d.c.	direct current
DIP	dual inline pin
EPROM	erasable programmable read-only memory
HP	Hewlett Packard
I/O	input and output
k	memory unit (2^{10}) 1024 words
LED	light emitting diode
mA	milliampere
PCB	printed circuit board
PFM	Plugging Factor Monitor
PFMEC	Plugging Factor Monitor Electronic Controller
PFMT	Plugging Factor Monitor Tester
SPSBP	Sample Point Selector Booster Pump
SSR	solid state relay
RAM	random access memory
ROM	read only memory
T1	first time measurement to fill tester filtrate tank
T2	second time measurement to fill tester filtrate tank

INTRODUCTION

The Yuma Desalting Test Facility was constructed to provide the Bureau of Reclamation with the needed data to design the proposed Yuma Desalting Plant near Yuma, Ariz. This plant would provide drainage water treatment for the Wellton-Mohawk Irrigation and Drainage District. The plant would subsequently reduce the salinity of Colorado River water delivered to Mexico.

The instrumentation requirements for the test facility included monitoring the plugging factor of the water at various points in the water pretreatment process. The measurement of this factor is used to indicate the amount of organic and inorganic particulate matter which is suspended in the water. The Chemical Engineering Group of the Applied Sciences Branch in the Division of Research designed a mechanical apparatus which contained the necessary piping, valves, and hardware to perform the plugging factor measurement. This design and the theoretical derivation of the testing techniques are discussed in reference [1].[1] The task of designing and constructing a controller for the mechanical apparatus that would automate the measurement process was assigned to the Instrumentation Branch of the Division of Research. The purpose of this report is to explain the maintenance and operation procedures for the controller, which will be referred to as the PFMEC (Plugging Factor Monitor Electronic Controller).

APPLICATIONS

As a whole, the PFM (Plugging Factor Monitor) includes the PFMEC, the PFMT (Plugging Factor Monitor Tester), and the SPSBP (Sample Point Selector Booster Pump). The PFM can be incorporated into any water treatment facility where the measurement of a plugging factor is required. Several of these monitors are being constructed for use at other sites. The Office of Water Research and Technology has requested a PFM for their test facilities, and one PFM will be retained by the Bureau for the model facility now being constructed in the Bureau's laboratories.

SYSTEM OVERVIEW

A general overview of the PFMEC is shown on figure 1. The basic function of the PFMEC is to operate the PFMT to provide plugging factor measurements on any or all of the six possible sample streams. The overview of the PFMEC shows that it is composed of essentially three parts:

1. Front panel (operator interface)
2. Processor card files and power supplies (computer)
3. Terminals on back panel (interface to PFMT and SPSBP).

An operations manual for the PFMEC is given in appendix A. The capabilities of the operator interface are briefly given:

- Seven-segment LED (light emitting diode) readout of the plugging factor, accurate to 0.1 percent, for each of the six possible streams.

- LED indication of which stream is being sampled.

- An alphanumeric printer that prints a record of all samples taken and all alarms that occur.

- System reset pushbutton for restart of the system. The reset also clears all past measurements.

- Battery backup switch to save the battery charge when not required.

- Four thumbdials for setting:

    1. T1 alarm limit (seconds)
    2. T2 alarm limit (seconds)
    3. Plugging factor alarm limit (percent)
    4. Cycle time (minutes)

- Audible alarm with reset button to reset alarms and a switch to disable the audible alarm if desired.

- Five LED alarms to indicate:

    1. Plugging factor over limit
    2. T1 over limit
    3. T2 over limit

---

[1] Numbers in brackets refer to items in the Bibliography.

4. Filter paper malfunction
5. Water pressure error

- LED and switch, one for each stream, to select and indicate which stream is to be sampled or activated.

- Seven-segment LED readout to indicate time in Julian days, hours, and minutes. Pushbuttons are provided to set the clock.

The card files and PCB's (printed circuit boards) will be discussed in the "System Hardware" section of this report.

The interface provided on the back panel is briefly described:

- Fourteen SSR (solid state relay) driver contact outputs capable of interrupting 120 volts of alternating current at 5 amperes allocated:
  1. Six for the SPSBP sample lines
  2. One to divert water from the PFMT to drain
  3. One for the air pressure head
  4. One for the paper (Millipore tape) feed motor
  5. One to drain or fill the filtrate tank
  6. Four spares

- Logic level input from the filtrate tank water level sensors

- Logic level input from the optical paper fault detector

- One 4- to 20-mA current input from the water pressure transducer

- Six 4- to 20-mA current outputs to provide external monitoring of the six stream plugging factors

- Dry contact output to interface to an external annunciator for remote alarm annunciation

The system drawings are given in this report and are divided into two sections. The first section, figures 1 through 25, defines the system hardware; and the second section, figures 26 through 32, contains the flowcharts which define the system program or software.

SYSTEM HARDWARE

The system hardware is shown in general form on figure 1, and figure 2 shows a checklist for construction. Figure 3 provides a physical layout of the PFMEC which is contained within a cabinet that is 508 mm (20 in) tall by 489 mm (19.25 in) wide by 470 mm (18.5 in) deep. The hardware of the system can be divided into the following units:

- Front panel
- Power supply tray (mounted in top of cabinet)
- Main card file (card access from rear)
- SSR card file (card access from rear)
- Back panel
- SPSBP
- PFMT

Front Panel

A layout showing the cutouts required for the front panel is shown on figure 4, and the wiring diagram is given on figure 6. The front panel provides for the mounting of four PCB's, four thumbdials, and the alphanumeric printer. Please note that all 16-pin DIP (dual inline pin) connectors connect to 16-pin sockets on the PCB's in the card files.

Clock Display Board.—The clock display board provides the Julian clock seven-segment display and pushbuttons for setting the clock. The external wiring for the board is shown on figure 6, and figure 23 shows the board schematic. Figure 6 shows that J7 and J8 are the 16-pin DIP connectors to the clock driver board, and that the 12-pin edge connector CBEC provides the connection to the pushbuttons.

Alarm Board.—The alarm board provides drive for the sonalert, alarm reset pushbutton, sonalert disable, five LED indicators, and the external alarm contact. A schematic is shown on figure 20. The external wiring for this board consists of one 36-pin edge connector that provides connection to the 16-pin DIP socket J9 on I/O (Input and Output) Board No. 1, the sonalert, the alarm reset pushbutton, and the external alarm contacts output to the back panel (fig. 6).

Display Board.—The display board drives the six front panel seven-segment LED displays and the six active-stream LED indicators. A schematic of this board is given on figure 21. External wiring includes six 16-pin DIP connectors (J1 through J6), one for each display, that connect to the three CMOS latch boards; and a 12-pin edge connector, DEEC, which provdes 5 volts of d-c power (fig. 6).

Stream Activate Board.—The stream activate board provides the six front panel toggle switches and LED's for selection and indication of the desired streams to be sampled. A schematic is given on figure 22. The external connections to the board include two 16-pin DIP connectors, one to I/O Board No. 1 (J10), and one to the stream activate switches (fig. 6).

Thumbdials.—The wiring for the four thumbdials is shown on sheet 2 of figure 6. Each thumbdial has one 16-pin DIP connector associated with it, and the four connectors are all located on I/O Board No. 2. The range of each thumbdial is:

Thumbdial	Range
T1 alarm limit	0 to 299 seconds
T2 alarm limit	0 to 299 seconds
Cycle time	0 to 99 minutes
Plugging factor alarm limit	0 to 99 percent

Printer.—The front panel printer is driven by parallel ASCII data (8 bits) through the 25-pin D-type connector on the back of the unit. This connector connects to slot J11 on I/O Board No. 1 as shown on sheet 2 of figure 6.

Power Supply Tray

The power supply wiring diagram is shown on figure 5; four power supplies are required. A small bracket is provided at the rear of the power supply tray that has jacks mounted on it for ease in measuring the power supply voltages. The tray is constructed to allow total removal from the cabinet if required. An a-c outlet is provided for the printer plug, and a switched a-c outlet is used to power the SSR contacts. The devices driven by these contacts are powered from this outlet. A 5-ampere fuse on the a-c power is also provided. A 5-volt, d-c, 2.6 ampere-hour battery is also provided to maintain the Julian clock, the six plugging factor measurements, and the current stream being sampled through power failure. The displays will go out on power loss; however, when power is restored, correct data should return to the displays.

Main Card File

The main card file holds fifteen 56-pin PCB's. The edge connectors for each slot have wire-wrap pins, and all wiring between connectors was done with wire-wrap equipment. The backplane wiring diagram for the card file is shown on figure 8. A brief explanation of the cards that mount in this main card file is given in the following subsections.

CPU Board No. 1.—The schematic for this board is given on figure 10. The board contains an Intel 8748 which has 1k (k = 1024), 8-bit bytes of EPROM (erasable programmable read-only memory); sixty-four 8-bit bytes of RAM (random access memory); and the processor—all on a 40-pin chip. Consult the Intel manual [2] for further information. The board also contains 2k, 8-bit bytes of expansion EPROM on an Intel 2716; some I/O multiplexing (Intel 8205); and the current stream count latch (CMOS latch 4076). This board resides in slot J31.

CPU Board No. 2.—The schematic for this board is shown on figure 11, and the board resides in slot J32 of the card file. This board provides the reset circuits for the CPU, the battery backup fail-over circuit, and a one-shot to sense the logic level signals for the water level sensors from the PFMT.

I/O Boards Nos. 1 and 2.—The schematics for these boards are given on figures 12 and 13, respectively. These boards provide the multiplexing of all input signals using the Intel 8243 I/O expander chip. An I/O map for all the points is given on figure 31. Note that column "Port Select" on the map refers to a selection of one of the five expanders available. Each expander has four, 4-bit-wide bidirectional ports. Consult the Intel manual [2] for a further explanation of I/O expansion.

CMOS Latch Boards Nos. 1, 2, and 3.—The schematic for Latch Board No. 1 is found on figure 14. Boards Nos. 2 and 3 are identical, and the schematic for them is on figure 15. These boards are used to latch and hold the plugging factor measurements for the six streams. Each board has six CMOS 4076, 4-bit-wide latches. Three of these six latches are required to save or hold the plugging factor data. Each digit is stored as BCD (binary coded decimal) data. Each card drives two plugging factor displays. These cards also drive the six current output boards provided for monitoring the plugging factor of each stream. During power failure, the cards are powered by the battery.

Clock Driver Board.—The schematic for this board is shown on figure 16. This board contains a 7213 clock-generator chip and the one-shots and counters required to form the Julian clock in BCD form. Multiplexers are also provided to read the clock with the microcomputer I/O lines.

Pressure Input Board.—The schematic for this board can be found on figure 17. The purpose of this board is to convert the 4- to 20-mA current input from the pressure transducer to digital data using a 12-bit, analog-to-digital converter. To provide some filtering, the four bottom bits of the converter are not used. Also, an isolation amplifier is used to isolate the transducer signal from the converter. Offset and gain adjustments are also provided. The procedure for calibrating this card can be found in appendix B.

Current Output Board.—The schematic for the Current Output Board is shown on figure 18. Six of these boards are required, one for each of the six streams. These boards provide a 4- to 20-mA current which corresponds to the plugging factor measured for the stream. Ideally, 4 mA equals a 0 percent plugging factor and 20 mA equals a 100 percent plugging factor. Each board contains a digital-to-analog converter and a voltage-to-current converter. Calibration procedures are given in appendix B.

SSR Card File

The SSR card file is constructed similar to the main card file, except it contains only seven card slots, all filled with SSR cards. The backplane wiring diagram for this card file is shown on figure 9.

SSR Board.—The schematic of this board is shown on figure 19. Each board contains two solid state relays rated at 120 volts a.c. and 5 amperes, and LED's are provided to indicate when the relays are energized (LED on = relay energized). Connections from the relay contacts to the back panel are made directly at the relay terminals.

Back Panel

The wiring diagram of the back panel is shown on figure 7. There are five 10-point terminal blocks (feed-through type) mounted on this panel, and labels are provided for each connection. To determine the function for the specific relays (Nos. 1 through 14), see figure 1.

The 5-pin amphenol connector P2 provides the connection for the water level sensors and the paper fault detector. A toggle switch is provided to test the remote alarm if desired. The points labeled "Mech. A/C Power" provide 120 volts of a.c. power to the PFMT electronics.

SPSBP

The wiring diagram for the SPSBP is shown on figure 24. There are two junction boxes, J3 and J4, mounted on the unit. These boxes provide a waterproof mount for terminal blocks used for connecting relays 1 through 6 to the six solenoid valves. Cables C1 and C2 provide connection from the PFMEC to the SPSBP.

PFMT

The wiring diagram for the PFMT is shown on figure 24. There are two boxes, J1 and J2, mounted on this unit. Box J1 contains the terminal box for connection of relays 7 through 10 to the solenoid valves and the paper feed motor. Cables C3 and C4 provide the link to the PFMEC at this box. Note that two of the four spare relays are wired into this box. Box J2 contains a PCB which provides the interface to the water level sensors and the optical paper fault sensor. The schematic of this PCB is shown on figure 26. Two reed relays provide a closed contact to the PFMEC when water in the filtrate tank makes contact with the low or high water-level probes. A third reed relay provides a closed contact when the toothed wheel on the Millipore tape feed roll does not block the path of light in the optical sensor. The PFMEC observes this contact for a change of state to detect if the paper roll is turning when the tape feed motor is operating.

SYSTEM SOFTWARE

There are four sets of listings shown in appendixes C, D, E, and F for the PFMEC software. The discussions of the software will be divided into the four areas which correspond to those software packages. All of the software for the system was created using a cross assembler which runs on a HP 2100 minicomputer. This system is identical to other cross assemblers that have been created by the Bureau [3], except that it assembles code for the Intel 8748. The mnemonics used by this system differ from the Intel mnemonics used in the Intel manual [2]. A table for converting the mnemonics from the Bureau to the Intel system is provided in appendix G. The flowcharts for the four software packages are shown on figure 26 through 32, and the titles assigned to the packages are:

1. PFMEC System
2. PFMEC System Without Printer Drivers
3. Printer Test
4. Hardware Maintenance

PFMEC System

The PFMEC system is the package that normally runs in the unit, while the other three packages are required for maintenance or debugging purposes only. To debug the system software, an Intel "Prompt 48" system monitor was used [4]. This system would only accommodate the 1k bytes of EPROM that reside on the Intel 8748. Since the PFMEC system requires more than 1k, it was necessary for the software to be broken down into two blocks, Nos. 2 and 3, for debug purposes with each block being debugged separately. The hardware maintenance package is required to quickly check the hardware of the PFMEC system.

The listings for the complete PFMEC system are shown in appendix C, and the flowcharts which correspond to these listings are shown on figures 26 through 30. The I/O and memory maps of this system are shown on figure 31. This package is divided into six software blocks which are described in the following subsections.

Timer/Counter.—The Timer/Counter block is flowcharted on figure 26, and is run on interrupt control. It is used to measure time in increments of 10 milliseconds and has a range up to 9999.99 seconds.

Executive.—The executive block of the system is flowcharted on figure 26. On power-up or when the reset button is pushed, the system first executes an initialization with a short delay, see sheet 1 of figure 26. Sheets 2, 3, and 4 of figure 26 show the main loop of the software which is repeated once for each stream sampled. The following listing shows the overall functions that are performed, the order they occur, and their location in the flowcharts.

1. Determine stream number to be sampled using "Stream Activate Switches" and output to stream LED's (top, sh. 2, fig. 26).

2. Advance Millipore tape and check for tape breakage. If error occurs, wait for alarm reset (bottom, sh. 2, fig. 26).

3. Select stream at SPSBP, lower pressure head, and begin flow through PFMT (top, sh. 3, fig. 26).

4. Fill filtrate tank, measure time T1, and check for pressure error or T1 exceeded limit (middle, sh. 3, fig. 26).

5. Drain filtrate tank and wait for selected cycle time (bottom, sh. 3, fig. 26).

6. Fill filtrate tank, measure time T2, and check for pressure error or T2 exceeded limit (top, sh. 4, fig. 26).

7. Stop flow to PFMT, calculate plugging factor, check for plugging factor limits exceeded, and print sample data and/or alarm on printer (bottom, sh. 4, fig. 26).

Miscellaneous Subroutines.—There are eight smaller subroutines that are used to support the executive portion of the system by performing generalized functions. These subroutines are flowcharted on figures 27 and 28. A brief explanation of these eight subroutines is:

1. DELAY—Uses timer/counter interrupt to delay a specified number of seconds.

2. VALVEON—Drives SPSBP solenoid valves to select stream to be sampled.

3. STROBE—Strobes data into the CMOS latches (CMOS Latch Boards Nos. 1, 2, and 3).

4. LATCH12—Stores plugging factor in the selected stream latches which, in turn, drives the display and the current outputs.

5. SONALERT—Turns on audible alarm.

6. CLOSEDWN—Causes flow through the PFMT to go to drain and lifts the pressure head.

7. STORE—Stores T1 or T2 time information.

8. THUMBDIAL—Reads selected thumbdial digits.

TIMEOUT.—The subroutine TIMEOUT is flowcharted on figure 28. The function of this subroutine is to measure time T1 or T2 and return that information to the timer/counter registers. Several checks are also performed while making the time measurements. First, a check of the "Pressure Option" switch mounted on I/O Board No. 1 is made. If a pressure transducer input is available, a check of the PFMT water pressure, (upstream from the Millipore tape) is made. If the pressure is out of limits, a pressure alarm is returned. If no pressure transducer input exists, TIMEOUT merely checks the time required for the filtrate tank water level to reach the low probe. If the time required is longer than 20 seconds, a pressure alarm will occur. Also, TIMEOUT checks the time being measured against the thumbdial limit. If that limit is exceeded, an alarm is returned.

PFCALC.—This subroutine is flowcharted on figure 29. The sole function of this subroutine is to perform the calculation 100-(100)(T1/T2). Since the variables T1 and T2 are both 24 bits wide (3 bytes), the calculation becomes rather complex and requires several shifts and BCD arithmetic operations. The subroutines SAVE and DAA are used to perform the general shift and store operations for PFCALC.

Printer Subroutines.—The subroutines used to drive the printer are flowcharted on figure 30. The main print subroutine, shown on sheet 1 of figure 30, functions to print out six possible messages:

1. Start of cycle
2. T1 alarm
3. Pressure alarm
4. T2 alarm
5. Plugging factor alarm
6. Normal message

The format of each of these messages is given in the operations manual in appendix A. Other subroutines support the main routine by generating particular parts of the messages. For example, subroutine ERR prints the alarm message, subroutine TIME reads the clock and prints the current time, and subroutine CALDAY calculates the calendar day from the Julian day and prints that information. The subroutine PRNT performs the actual drive of the printer, and is flowcharted at the top of sheet 3 of figure 30.

PFMEC System Without Printer Subroutines

The listings of this system are given in appendix D. As previously mentioned, this system was generated for debugging purposes, and is identical to the PFMEC system software except that the printer subroutines have been eliminated. This reduces the system size enough so that it can reside in the 1k by 8 EPROM of the Intel 8748 and can be debugged using the Promp 48. The system operates like the normal system except no printer messages are generated.

Printer Test

The listings of this system can be found in appendix E. This system allows the debugging of the printer subroutines and includes the PRNTEST subroutine (sh. 3, fig. 30) and the printer subroutines. The PRNTEST subroutine reads the front panel stream select switches and prints one of the six possible printer messages based on the settings of those switches. The operation of this printer test system is given in the operations manual in appendix A. Please note that this system is used as a test of the printer software; the printer hardware is tested with the hardware maintenance package.

Hardware Maintenance

This software package is flowcharted on figure 32, and the system listings are given in appendix F. The system operates similar to PRNTEST in that it reads the stream count switches to determine which of the 34 possible tests are to be performed. These tests can be used to check all of the hardware functions of the PFMEC. The operation of the maintenance system is given in the operations manual in appendix A.

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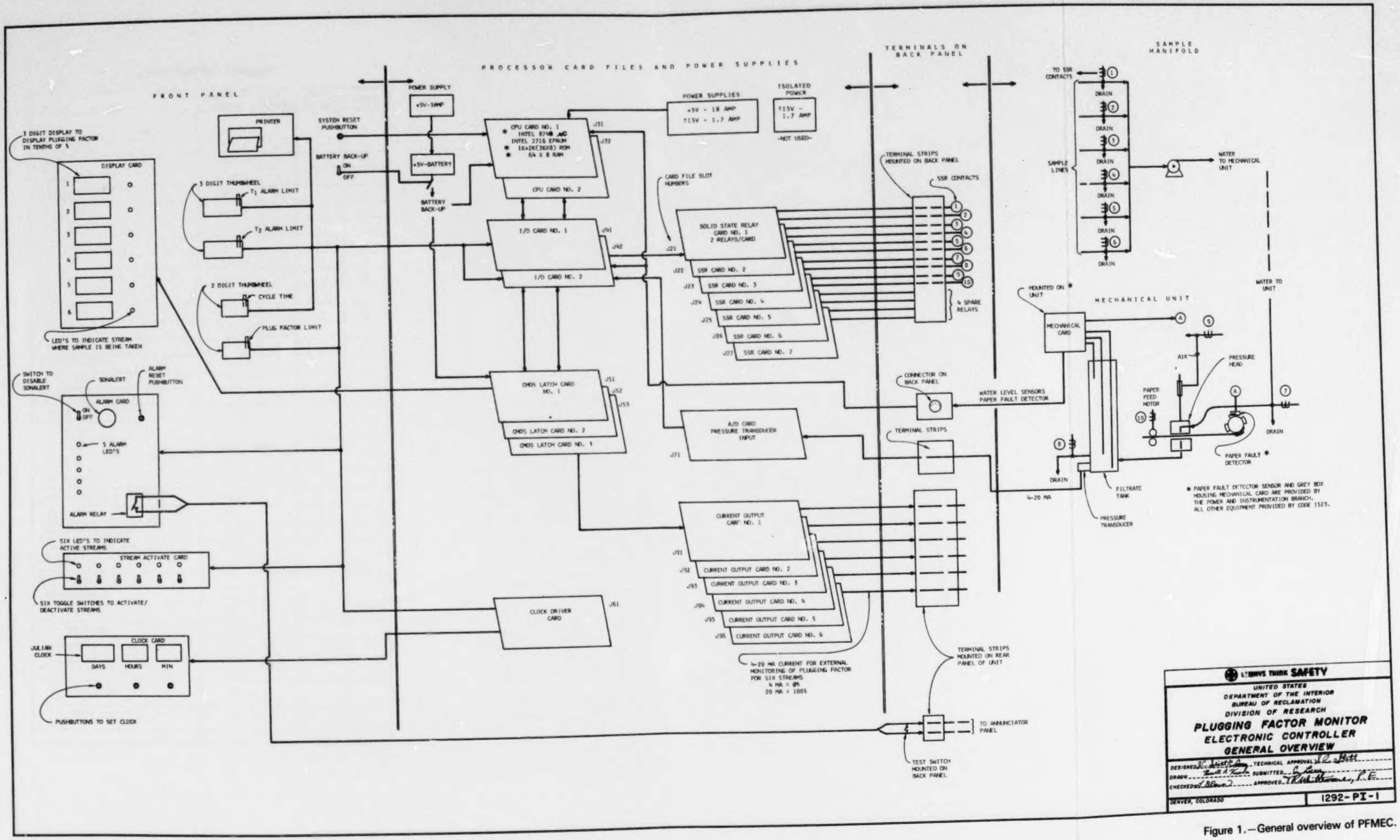
[2] *MCS-48 Family of Single-Chip Computers—User's Manual,* Manual No. 9800270D, Intel Corp., July 1978.

[3] Whittemore, T. R., and S. C. Stitt, *A Microcomputer Software Development System,* Report No. REC-ERC-78-9, Bureau of Reclamation, Denver, Colo., Sept. 1978.

[4] *Prompt 48 Microcomputer User's Manual,* Manual No. 9800402C, Intel Corp. 1978.


FRONT PANEL
PROCESSOR CARD FILES AND POWER SUPPLIES
TERMINALS ON BACK PANEL
SAMPLE MANIFOLD
3 DIGIT DISPLAY TO DISPLAY PLUGGING FACTOR IN TENTHS OF %
DISPLAY CARD
1
2
3
4
5
6
LED'S TO INDICATE STREAM WHERE SAMPLE IS BEING TAKEN
PRINTER
3 DIGIT THUMBWHEEL
T_1 ALARM LIMIT
T_2 ALARM LIMIT
2 DIGIT THUMBWHEEL
CYCLE TIME
PLUG FACTOR LIMIT
SWITCH TO DISABLE SONALERT
SONALERT
ALARM RESET PUSHBUTTON
ALARM CARD
ON
OFF
5 ALARM LED'S
ALARM RELAY
SIX LED'S TO INDICATE ACTIVE STREAMS
STREAM ACTIVATE CARD
SIX TOGGLE SWITCHES TO ACTIVATE/DEACTIVATE STREAMS
CLOCK CARD
JULIAN CLOCK
DAYS
HOURS
MIN
PUSHBUTTONS TO SET CLOCK
SYSTEM RESET PUSHBUTTON
BATTERY BACK-UP
ON
OFF
POWER SUPPLY
+5V-3AMP
+5V-BATTERY
BATTERY BACK-UP
CPU CARD NO. 1
* INTEL 8748 µC
INTEL 2716 EPROM
* 1K+2K(3KX8) ROM
* 64 X 8 RAM
CPU CARD NO. 2
J31
J32
POWER SUPPLIES
+5V - 18 AMP
±15V - 1.7 AMP
ISOLATED POWER
±15V - 1.7 AMP
-NOT USED-
CARD FILE SLOT NUMBERS
I/O CARD NO. 1
I/O CARD NO. 2
J41
J42
SOLID STATE RELAY CARD NO. 1 2 RELAYS/CARD
J21
J22 SSR CARD NO. 2
J23 SSR CARD NO. 3
J24 SSR CARD NO. 4
J25 SSR CARD NO. 5
J26 SSR CARD NO. 6
J27 SSR CARD NO. 7
CMOS LATCH CARD NO. 1
CMOS LATCH CARD NO. 2
CMOS LATCH CARD NO. 3
J51
J52
J53
A/D CARD PRESSURE TRANSDUCER INPUT
J71
CLOCK DRIVER CARD
J61
CURRENT OUTPUT CARD NO. 1
J91
J92 CURRENT OUTPUT CARD NO. 2
J93 CURRENT OUTPUT CARD NO. 3
J94 CURRENT OUTPUT CARD NO. 4
J95 CURRENT OUTPUT CARD NO. 5
J96 CURRENT OUTPUT CARD NO. 6
4-20 MA CURRENT FOR EXTERNAL MONITORING OF PLUGGING FACTOR FOR SIX STREAMS
4 MA = 0%
20 MA = 100%
TERMINAL STRIPS MOUNTED ON BACK PANEL
SSR CONTACTS
①
②
③
④
⑤
⑥
⑦
⑧
⑨
⑩
4 SPARE RELAYS
CONNECTOR ON BACK PANEL
WATER LEVEL SENSORS
PAPER FAULT DETECTOR
TERMINAL STRIPS
TERMINAL STRIPS MOUNTED ON REAR PANEL OF UNIT
TO ANNUNCIATOR PANEL
TEST SWITCH MOUNTED ON BACK PANEL
TO SSR CONTACTS
DRAIN
SAMPLE LINES
WATER TO MECHANICAL UNIT
WATER TO UNIT
MOUNTED ON UNIT *
MECHANICAL UNIT
MECHANICAL CARD
Ⓐ
AIR
PRESSURE HEAD
PAPER FEED MOTOR
PAPER FAULT DETECTOR *
DRAIN
4-20 MA
FILTRATE TANK
PRESSURE TRANSDUCER
* PAPER FAULT DETECTOR SENSOR AND GREY BOX HOUSING MECHANICAL CARD ARE PROVIDED BY THE POWER AND INSTRUMENTATION BRANCH. ALL OTHER EQUIPMENT PROVIDED BY CODE 1523.
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DIVISION OF RESEARCH
PLUGGING FACTOR MONITOR
ELECTRONIC CONTROLLER
GENERAL OVERVIEW
DESIGNED
TECHNICAL APPROVAL
DRAWN
SUBMITTED
CHECKED
APPROVED
DENVER, COLORADO
1292-PI-1

Figure 1.—General overview of PFMEC.

CONSTRUCTION SUMMARY

	REFERENCE DRAWING	NO. REQUIRED	BUILT/ INSTALLED	TESTED
CABINET - PRE-FAB (EQUIPTO MOD. SC-1918-19)	1292-PI-5	1	NA	NA
POWER SUPPLY RACK	1292-PI-5	1		
HARDWARE	1292-PI-3	NA		NA
RACK WIRING	1292-PI-5	NA		
FRONT PANEL	1292-PI-4	1		
DISPLAY CARD	1292-PI-22	1		
ALARM CARD	1292-PI-21	1		
STREAM ACTIVATE CARD	1292-PI-23	1		
CLOCK CARD	1292-PI-24	1		
MOUNT COMPONENTS ON PANEL	1292-PI-3	NA		NA
PANEL WIRING	1292-PI-6,7	NA		
BACK PANEL/DOOR	1292-PI-3,8	1		NA
HARDWARE CONSTRUCTION	1292-PI-3,8	NA		
WIRING/CABLES	1292-PI-8	NA		
MAIN CARD FILE WIRING	1292-PI-9	NA		
SSR CARD FILE WIRING	1292-PI-10	NA		
PRINTED CIRCUIT CARDS		NA		
CPU CARD NO. 1	1292-PI-11	1		
CPU CARD NO. 2	1292-PI-12	1		
I/O CARD NO. 1	1292-PI-13	1		
I/O CARD NO. 2	1292-PI-14	1		
CMOS LATCH BOARD NO. 1	1292-PI-15	1		
CMOS LATCH BOARD NO. 2/ NO. 3	1292-PI-16	2		
CLOCK DRIVER BOARD	1292-PI-17	1		
A/D PRESSURE TRANSDUCER CARD	1292-PI-18	1		
4-20 MA CURRENT OUTPUT CARD	1292-PI-19	6		
SSR CARD	1292-PI-20	7		
MECHANICAL UNIT		NA		
MECHANICAL CARD	1292-PI-26	1		
GREY BOX (PRE-FAB)	1292-PI-25	1		
PAPER FAULT SENSORS	1292-PI-25	2		
UNIT WIRING	1292-PI-25	NA		
CABLE FROM PFM TO MANIFOLD CRIMP LUGS BOTH ENDS	1292-PI-25	1		
CABLE FROM PFM TO MECH. U. T CRIMP LUGS BOTH ENDS	1292-PI-25	1		
CABLE FROM GREY BOX TO PFM 5 PIN AMPHENOL MALE (BOTH ENDS)	1292-PI-25	1		

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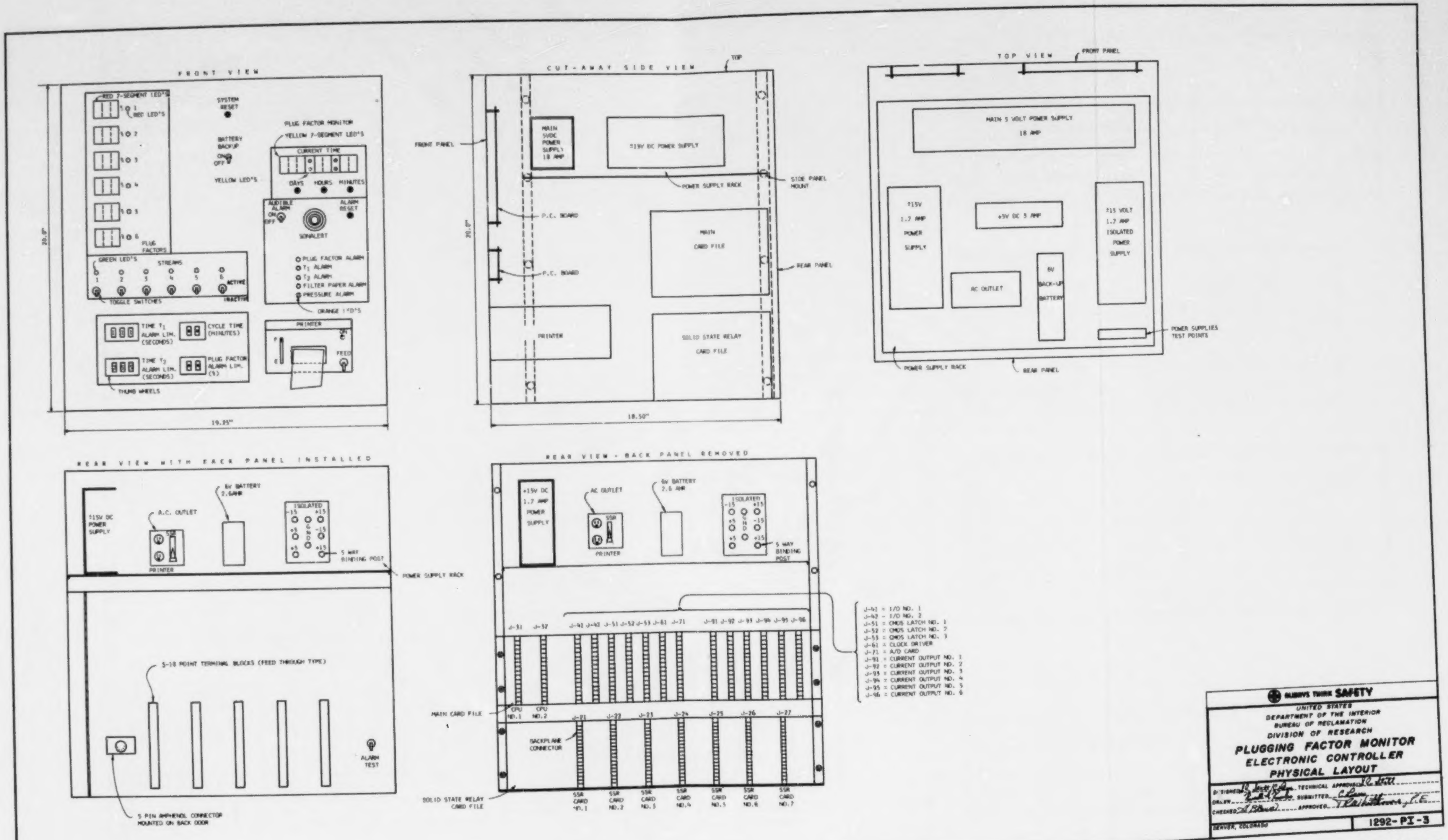
PLUGGING FACTOR MONITOR
ELECTRONIC CONTROLLER
CONSTRUCTION SUMMARY

DESIGNED [illegible] TECHNICAL APPROVAL [illegible]
DRAWN [illegible] SUBMITTED [illegible]
CHECKED [illegible] APPROVED [illegible], P.E.

DENVER, COLORADO
1292-PI-2

Figure 2.—Construction summary for PFMEC.


FRONT VIEW
RED 7-SEGMENT LED'S
RED LED'S
SYSTEM RESET
PLUG FACTOR MONITOR
YELLOW 7-SEGMENT LED'S
BATTERY BACKUP
ON
OFF
YELLOW LED'S
CURRENT TIME
DAYS
HOURS
MINUTES
AUDIBLE ALARM
ALARM RESET
SONALERT
PLUG FACTORS
GREEN LED'S
STREAMS
1 2 3 4 5 6
ACTIVE
INACTIVE
TOGGLE SWITCHES
PLUG FACTOR ALARM
T1 ALARM
T2 ALARM
FILTER PAPER ALARM
PRESSURE ALARM
ORANGE LED'S
TIME T1 ALARM LIM. (SECONDS)
CYCLE TIME (MINUTES)
TIME T2 ALARM LIM. (SECONDS)
PLUG FACTOR ALARM LIM. (%)
THUMB WHEELS
PRINTER
FEED
20.0"
19.25"
CUT-AWAY SIDE VIEW
TOP
FRONT PANEL
MAIN 5VDC POWER SUPPLY 18 AMP
±15V DC POWER SUPPLY
POWER SUPPLY RACK
SIDE PANEL MOUNT
P.C. BOARD
P.C. BOARD
MAIN CARD FILE
REAR PANEL
PRINTER
SOLID STATE RELAY CARD FILE
20.0"
18.50"
TOP VIEW
FRONT PANEL
MAIN 5 VOLT POWER SUPPLY 18 AMP
±15V 1.7 AMP POWER SUPPLY
+5V DC 3 AMP
±15 VOLT 1.7 AMP ISOLATED POWER SUPPLY
AC OUTLET
6V BACK-UP BATTERY
POWER SUPPLIES TEST POINTS
POWER SUPPLY RACK
REAR PANEL
REAR VIEW WITH BACK PANEL INSTALLED
±15V DC POWER SUPPLY
A.C. OUTLET
SSR
PRINTER
6V BATTERY 2.6AHR
ISOLATED
-15 +15
+5 -15
+5 +15
GND
5 WAY BINDING POST
POWER SUPPLY RACK
5-18 POINT TERMINAL BLOCKS (FEED THROUGH TYPE)
ALARM TEST
5 PIN AMPHENOL CONNECTOR MOUNTED ON BACK DOOR
REAR VIEW - BACK PANEL REMOVED
+15V DC 1.7 AMP POWER SUPPLY
AC OUTLET
SSR
PRINTER
6V BATTERY 2.6 AHR
ISOLATED
5 WAY BINDING POST
J-31 J-32 J-41 J-42 J-51 J-52 J-53 J-61 J-71 J-91 J-92 J-93 J-94 J-95 J-96
MAIN CARD FILE
CPU NO.1
CPU NO.2
J-21 J-22 J-23 J-24 J-25 J-26 J-27
BACKPLANE CONNECTOR
SOLID STATE RELAY CARD FILE
SSR CARD NO.1
SSR CARD NO.2
SSR CARD NO.3
SSR CARD NO.4
SSR CARD NO.5
SSR CARD NO.6
SSR CARD NO.7
J-41 = I/O NO. 1
J-42 - I/O NO. 2
J-51 = CMOS LATCH NO. 1
J-52 = CMOS LATCH NO. 2
J-53 = CMOS LATCH NO. 3
J-61 = CLOCK DRIVER
J-71 = A/D CARD
J-91 = CURRENT OUTPUT NO. 1
J-92 = CURRENT OUTPUT NO. 2
J-93 = CURRENT OUTPUT NO. 3
J-94 = CURRENT OUTPUT NO. 4
J-95 = CURRENT OUTPUT NO. 5
J-96 = CURRENT OUTPUT NO. 6
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ELECTRONIC CONTROLLER
PHYSICAL LAYOUT
DESIGNED
DRAWN
CHECKED
TECHNICAL APPROVAL
SUBMITTED
APPROVED
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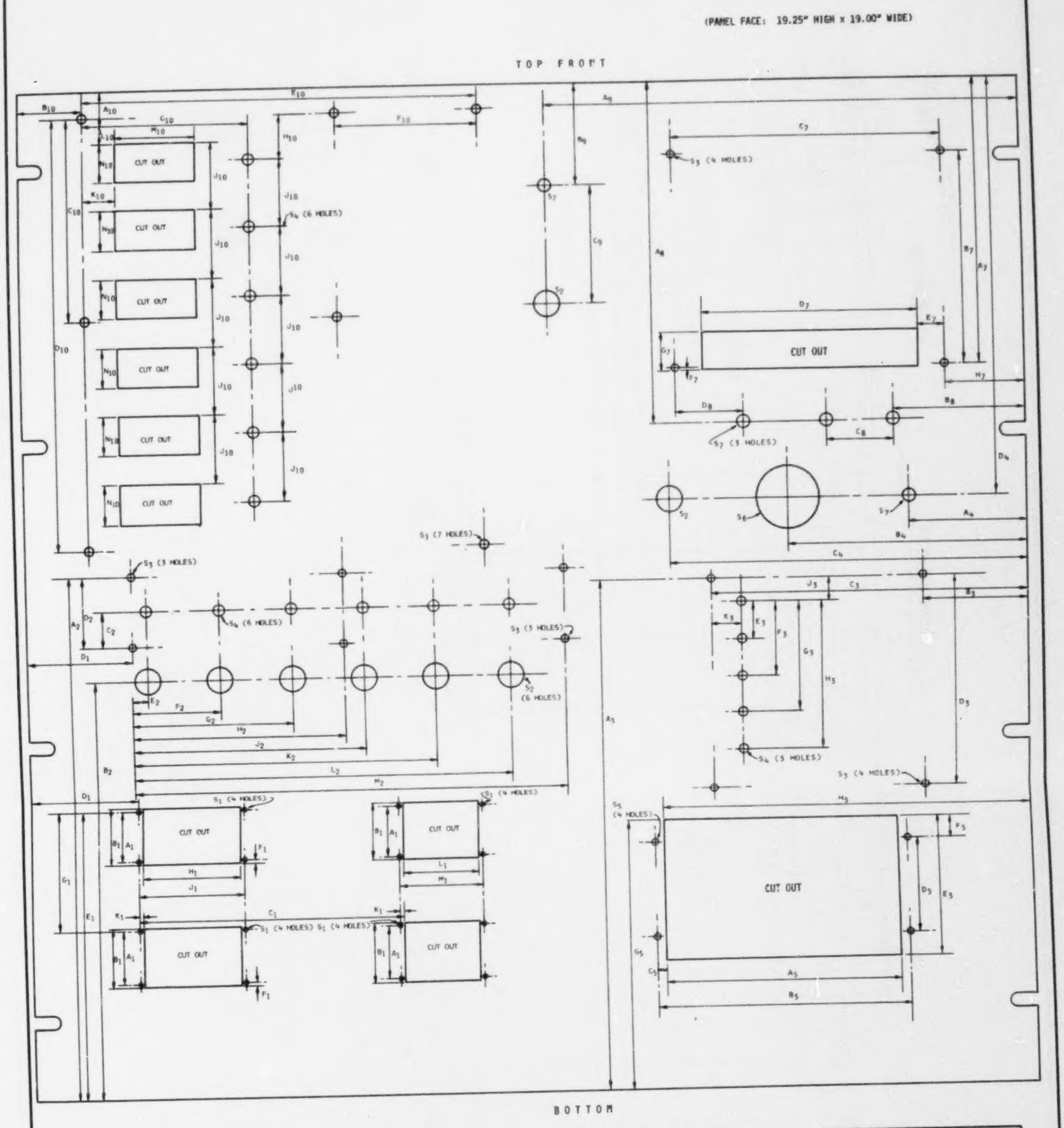
1292-PI-3

Figure 3.—Physical layout of PFMEC in cabinet.



(PANEL FACE: 19.25" HIGH x 19.00" WIDE)
TOP FRONT
BOTTOM
CUT OUT
S_3 (4 HOLES)
S_4 (6 HOLES)
S_7 (3 HOLES)
S_3 (7 HOLES)
S_3 (3 HOLES)
S_2 (6 HOLES)
S_4 (5 HOLES)
S_5 (4 HOLES)
S_1 (4 HOLES)
S_2
S_6
S_7

DIMENSION (INCHES)		COMMENTS
A_1	.900	(±.010)
B_1	.980	(±.010)
C_1	5.00	
D_1	2.063	(I.E., 2-1/6)
E_1	5.50	
F_1	.040	
G_1	2.20	
H_1	1.93	(±.010)
J_1	2.09	(±.010)
K_1	.080	
L_1	1.45	(±.010)
M_1	1.59	(±.010)
A_2	10.00	
B_2	8.00	
C_2	.700	
D_2	1.30	
E_2	.200	
F_2	1.55	
G_2	2.90	
H_2	4.00	
J_2	4.25	
K_2	5.65	
L_2	7.00	
M_2	8.20	

DIMENSIONS (INCHES)		COMMENTS
A_3	9.75	
B_3	2.00	
C_3	6.00	
D_3	4.00	
E_3	.700	
F_3	1.40	
G_3	2.10	
H_3	2.80	
J_3	.425	
K_3	.525	
A_4	2.25	
B_4	4.50	
C_4	6.75	
D_4	8.00	
A_5	4.50	(±.010)
B_5	4.750	(±.005)
C_5	.130	
D_5	1.875	(±.005)
E_5	2.72	(±.010)
F_5	.420	
G_5	5.125	
H_5	7.00	

DIMENSIONS (INCHES)		COMMENTS
A_7	5.50	
B_7	4.10	
C_7	5.10	
D_7	4.10	
E_7	.500	
F_7	.051	(±.010)
G_7	.750	
H_7	1.50	
A_8	6.50	
B_8	2.50	
C_8	1.28	
D_8	1.25	
A_9	9.00	
B_9	2.00	
C_9	2.25	
A_{10}	.500	
B_{10}	1.25	
C_{10}	3.90	
D_{10}	8.25	
E_{10}	7.50	
F_{10}	2.70	
G_{10}	3.15	(±.010)
H_{10}	.850	(±.010)
J_{10}	1.30	(±.010)
K_{10}	.600	(±.010)

DIMENSIONS (INCHES)		COMMENTS
L_{10}	.525	(±.010)
M_{10}	1.50	
N_{10}	.750	

HOLE DIAMETER (INCHES)		COMMENTS
S_1	.110	(#35 BIT)
S_2	.475	
S_3	.161	(#20 BIT)
S_4	.201	(#7 BIT)
S_5	.125	(1/8-IN BIT)
S_6	1.150	
S_7	.250	(1/4-IN BIT)

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PLUGGING FACTOR MONITOR
ELECTRONIC CONTROLLER
FRONT PANEL CUTOUTS

DESIGNED .... TECHNICAL APPROVAL ....
DRAWN .... SUBMITTED ....
CHECKED .... APPROVED .... P.E.
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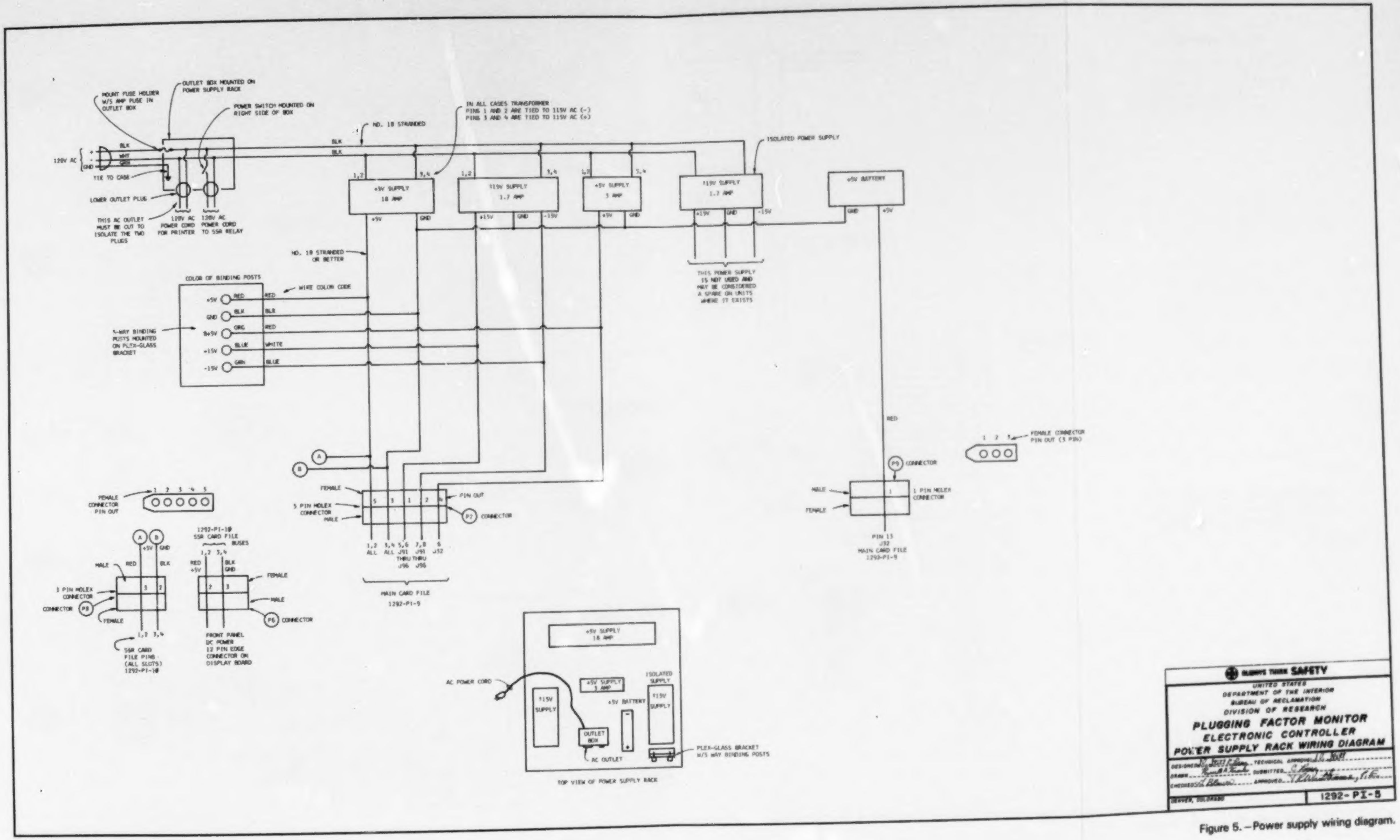
1292-PI-4

Figure 4.—Cutouts required for front panel of PFMEC.


MOUNT FUSE HOLDER W/5 AMP FUSE IN OUTLET BOX
OUTLET BOX MOUNTED ON POWER SUPPLY RACK
POWER SWITCH MOUNTED ON RIGHT SIDE OF BOX
NO. 18 STRANDED
IN ALL CASES TRANSFORMER PINS 1 AND 2 ARE TIED TO 115V AC (-) PINS 3 AND 4 ARE TIED TO 115V AC (+)
ISOLATED POWER SUPPLY
120V AC
+
-
GND
BLK
WHT
GRN
BLK
BLK
TIE TO CASE
LOWER OUTLET PLUG
THIS AC OUTLET MUST BE CUT TO ISOLATE THE TWO PLUGS
120V AC POWER CORD FOR PRINTER
120V AC POWER CORD TO SSR RELAY
1,2
3,4
+5V SUPPLY 18 AMP
+5V
GND
±15V SUPPLY 1.7 AMP
+15V
GND
-15V
+5V SUPPLY 3 AMP
+5V
GND
±15V SUPPLY 1.7 AMP
+15V
GND
-15V
+5V BATTERY
GND
+5V
THIS POWER SUPPLY IS NOT USED AND MAY BE CONSIDERED A SPARE ON UNITS WHERE IT EXISTS
NO. 18 STRANDED OR BETTER
COLOR OF BINDING POSTS
WIRE COLOR CODE
+5V RED RED
GND BLK BLK
B+5V ORG RED
+15V BLUE WHITE
-15V GRN BLUE
5-WAY BINDING POSTS MOUNTED ON PLEX-GLASS BRACKET
RED
A
B
FEMALE
5 PIN MOLEX CONNECTOR
MALE
5 3 1 2 4
PIN OUT
P7 CONNECTOR
1,2 ALL
3,4 ALL
5,6 J91 THRU J96
7,8 J91 THRU J96
6 J32
MAIN CARD FILE 1292-PI-9
FEMALE CONNECTOR PIN OUT
1 2 3 4 5
A B
+5V GND
MALE
RED
BLK
3 PIN MOLEX CONNECTOR
CONNECTOR P8
FEMALE
3 2
1,2 3,4
SSR CARD FILE PINS (ALL SLOTS) 1292-PI-10
1292-PI-10 SSR CARD FILE BUSES
1,2 3,4
RED +5V
BLK GND
2 3
FEMALE
MALE
P6 CONNECTOR
FRONT PANEL DC POWER 12 PIN EDGE CONNECTOR ON DISPLAY BOARD
P9 CONNECTOR
MALE
FEMALE
1
1 PIN MOLEX CONNECTOR
PIN 13 J32 MAIN CARD FILE 1292-PI-9
1 2 3
FEMALE CONNECTOR PIN OUT (3 PIN)
+5V SUPPLY 18 AMP
AC POWER CORD
±15V SUPPLY
+5V SUPPLY 5 AMP
+5V BATTERY
ISOLATED SUPPLY
±15V SUPPLY
OUTLET BOX
AC OUTLET
PLEX-GLASS BRACKET W/5 WAY BINDING POSTS
TOP VIEW OF POWER SUPPLY RACK
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ELECTRONIC CONTROLLER
POWER SUPPLY RACK WIRING DIAGRAM
DESIGNED
TECHNICAL APPROVAL
DRAWN
SUBMITTED
CHECKED
APPROVED
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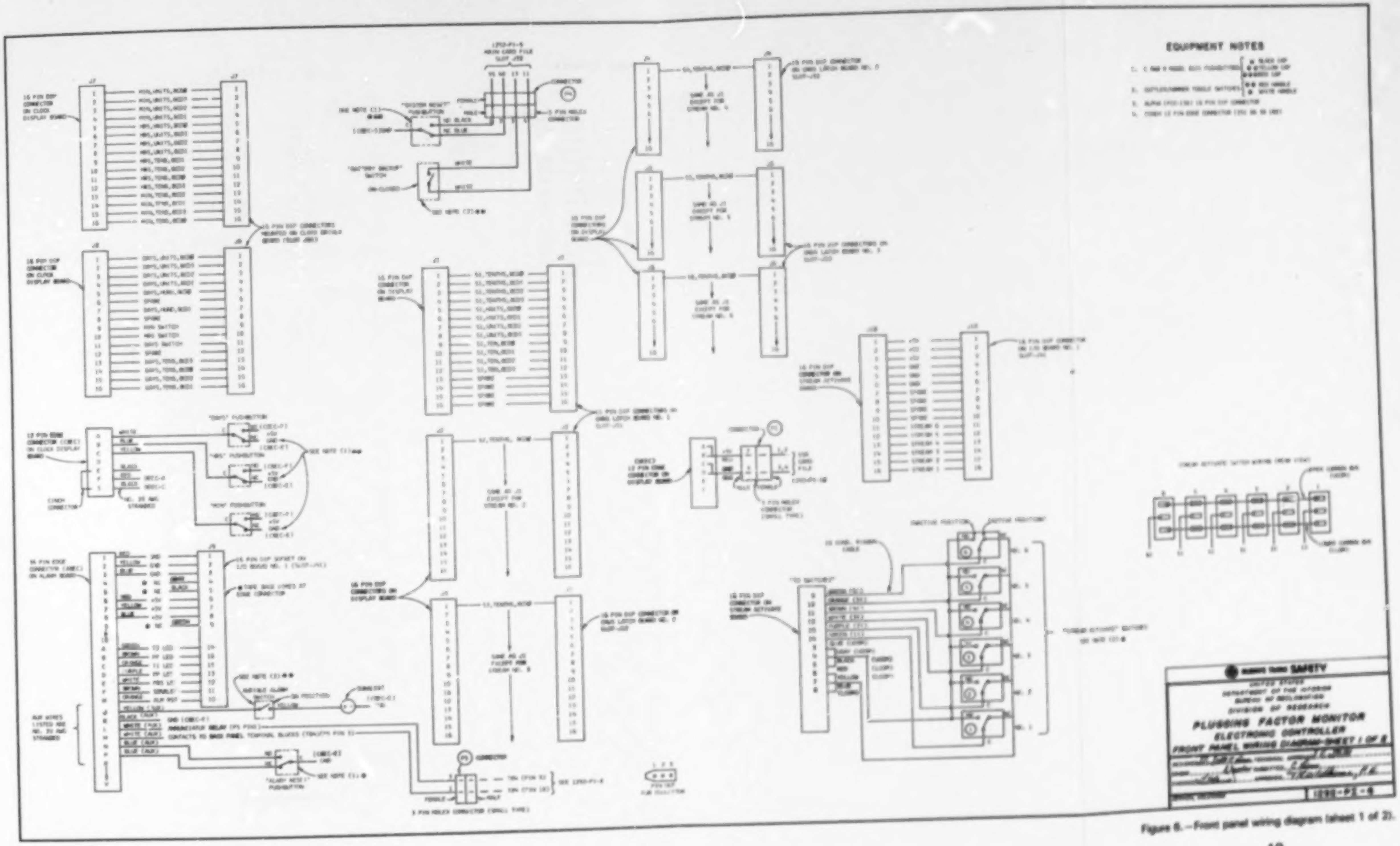
1292-PI-5

Figure 5. —Power supply wiring diagram.


EQUIPMENT NOTES
SAFETY
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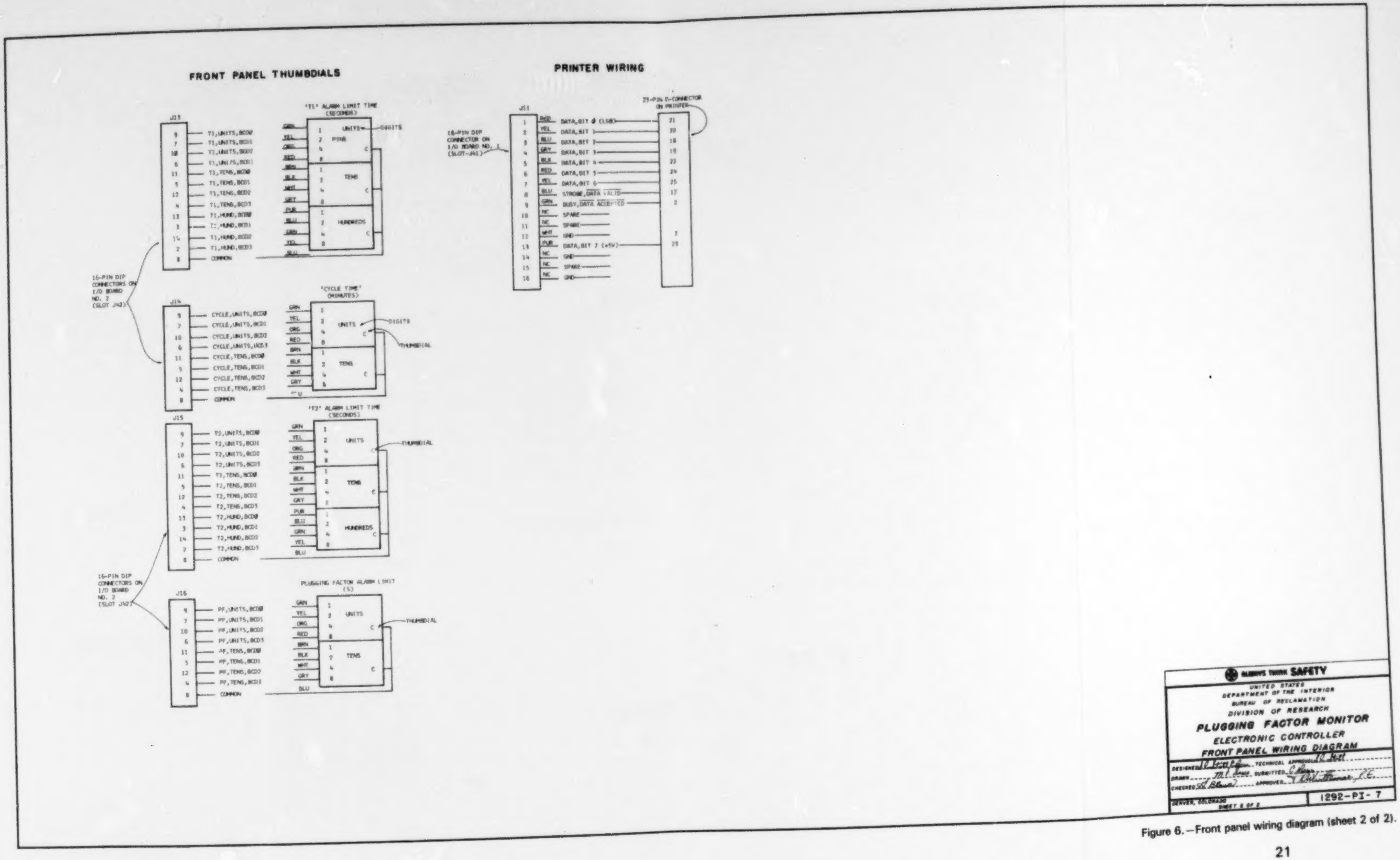
ELECTRONIC CONTROLLER
FRONT PANEL WIRING DIAGRAM-SHEET 1 OF 2

Figure 6.—Front panel wiring diagram (sheet 1 of 2).


FRONT PANEL THUMBDIALS
J13
T1,UNITS,BCD0
T1,UNITS,BCD1
T1,UNITS,BCD2
T1,UNITS,BCD3
T1,TENS,BCD0
T1,TENS,BCD1
T1,TENS,BCD2
T1,TENS,BCD3
T1,HUND,BCD0
T1,HUND,BCD1
T1,HUND,BCD2
T1,HUND,BCD3
COMMON
'T1' ALARM LIMIT TIME (SECONDS)
UNITS
PINS
TENS
HUNDREDS
DIGITS
16-PIN DIP CONNECTORS ON I/O BOARD NO. 2 (SLOT J42)
J14
CYCLE,UNITS,BCD0
CYCLE,UNITS,BCD1
CYCLE,UNITS,BCD2
CYCLE,UNITS,BCD3
CYCLE,TENS,BCD0
CYCLE,TENS,BCD1
CYCLE,TENS,BCD2
CYCLE,TENS,BCD3
'CYCLE TIME' (MINUTES)
THUMBDIAL
J15
T2,UNITS,BCD0
T2,UNITS,BCD1
T2,UNITS,BCD2
T2,UNITS,BCD3
T2,TENS,BCD0
T2,TENS,BCD1
T2,TENS,BCD2
T2,TENS,BCD3
T2,HUND,BCD0
T2,HUND,BCD1
T2,HUND,BCD2
T2,HUND,BCD3
'T2' ALARM LIMIT TIME (SECONDS)
J16
PF,UNITS,BCD0
PF,UNITS,BCD1
PF,UNITS,BCD2
PF,UNITS,BCD3
PF,TENS,BCD0
PF,TENS,BCD1
PF,TENS,BCD2
PF,TENS,BCD3
PLUGGING FACTOR ALARM LIMIT (%)
GRN YEL ORG RED BRN BLK WHT GRY PUR BLU
PRINTER WIRING
J11
16-PIN DIP CONNECTOR ON I/O BOARD NO. 1 (SLOT-J41)
25-PIN D-CONNECTOR ON PRINTER
DATA,BIT 0 (LSB)
DATA,BIT 1
DATA,BIT 2
DATA,BIT 3
DATA,BIT 4
DATA,BIT 5
DATA,BIT 6
STROBE,DATA VALID
BUSY,DATA ACCEPTED
SPARE
GND
DATA,BIT 7 (+5V)
NC
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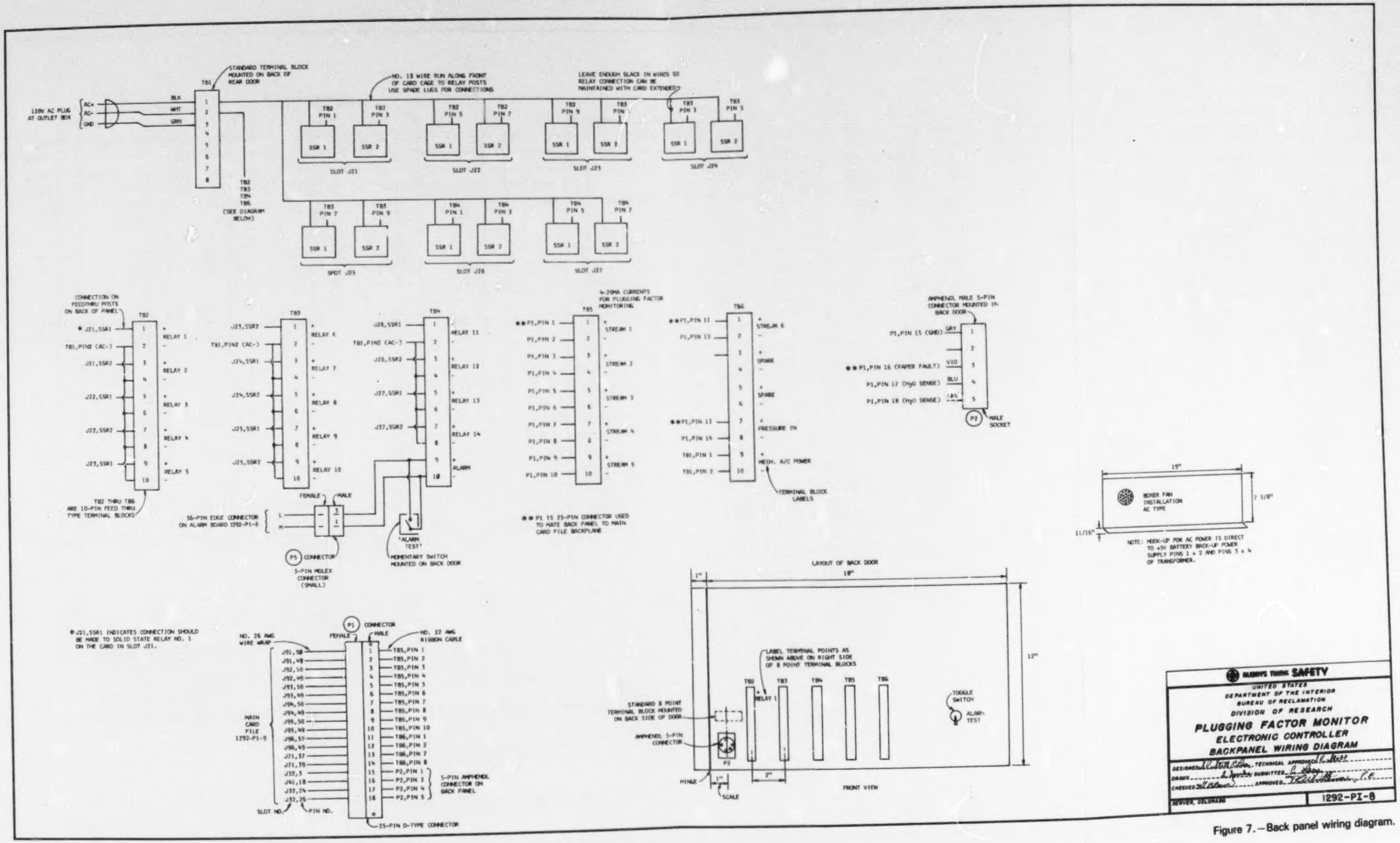
ELECTRONIC CONTROLLER
FRONT PANEL WIRING DIAGRAM
DESIGNED
TECHNICAL APPROVAL
DRAWN
SUBMITTED
CHECKED
APPROVED
DENVER, COLORADO
SHEET 2 OF 2
1292-PI-7

Figure 6.—Front panel wiring diagram (sheet 2 of 2).


120V AC PLUG AT OUTLET BOX
AC+
AC-
GND
BLK
WHT
GRN
TB1
STANDARD TERMINAL BLOCK MOUNTED ON BACK OF REAR DOOR
TB2 TB3 TB4 TB6 (SEE DIAGRAM BELOW)
NO. 18 WIRE RUN ALONG FRONT OF CARD CAGE TO RELAY POSTS USE SPADE LUGS FOR CONNECTIONS
LEAVE ENOUGH SLACK IN WIRES SO RELAY CONNECTION CAN BE MAINTAINED WITH CARD EXTENDED
TB2 PIN 1
TB2 PIN 3
TB2 PIN 5
TB2 PIN 7
TB2 PIN 9
TB3 PIN 1
TB3 PIN 3
TB3 PIN 5
SSR 1
SSR 2
SLOT J21
SLOT J22
SLOT J23
SLOT J24
TB3 PIN 7
TB3 PIN 9
TB4 PIN 1
TB4 PIN 3
TB4 PIN 5
TB4 PIN 7
SPOT J25
SLOT J26
SLOT J27
CONNECTION ON FEEDTHRU POSTS ON BACK OF PANEL
TB2
* J21,SSR1
TB1,PIN2 (AC-)
J21,SSR2
J22,SSR1
J22,SSR2
J23,SSR1
RELAY 1
RELAY 2
RELAY 3
RELAY 4
RELAY 5
TB2 THRU TB6 ARE 10-PIN FEED THRU TYPE TERMINAL BLOCKS
TB3
J23,SSR2
TB1,PIN2 (AC-)
J24,SSR1
J24,SSR2
J25,SSR1
J25,SSR2
RELAY 6
RELAY 7
RELAY 8
RELAY 9
RELAY 10
TB4
J26,SSR1
TB1,PIN2 (AC-)
J26,SSR2
J27,SSR1
J27,SSR2
RELAY 11
RELAY 12
RELAY 13
RELAY 14
ALARM
FEMALE
MALE
36-PIN EDGE CONNECTOR ON ALARM BOARD 1292-P1-6
L
M
P5 CONNECTOR
3-PIN MOLEX CONNECTOR (SMALL)
'ALARM TEST'
MOMENTARY SWITCH MOUNTED ON BACK DOOR
4-20MA CURRENTS FOR PLUGGING FACTOR MONITORING
TB5
**P1,PIN 1
P1,PIN 2
P1,PIN 3
P1,PIN 4
P1,PIN 5
P1,PIN 6
P1,PIN 7
P1,PIN 8
P1,PIN 9
P1,PIN 10
STREAM 1
STREAM 2
STREAM 3
STREAM 4
STREAM 5
** P1 IS 25-PIN CONNECTOR USED TO MATE BACK PANEL TO MAIN CARD FILE BACKPLANE
TB6
**P1,PIN 11
P1,PIN 12
**P1,PIN 13
P1,PIN 14
TB1,PIN 1
TB1,PIN 2
STREAM 6
SPARE
SPARE
PRESSURE IN
MECH. A/C POWER
TERMINAL BLOCK LABELS
AMPHENOL MALE 5-PIN CONNECTOR MOUNTED IN BACK DOOR
P1,PIN 15 (GND)
**P1,PIN 16 (PAPER FAULT)
P1,PIN 17 (H2O SENSE)
P1,PIN 18 (H2O SENSE)
GRY
VIO
BLU
LBN
P2
MALE SOCKET
*J21,SSR1 INDICATES CONNECTION SHOULD BE MADE TO SOLID STATE RELAY NO. 1 ON THE CARD IN SLOT J21.
P1 CONNECTOR
FEMALE
MALE
NO. 26 AWG WIRE WRAP
NO. 22 AWG RIBBON CABLE
MAIN CARD FILE 1292-P1-9
J91,50
J91,49
J92,50
J92,49
J93,50
J93,49
J94,50
J94,49
J95,50
J95,49
J96,50
J96,49
J71,37
J71,39
J32,3
J41,18
J32,24
J32,26
SLOT NO.
PIN NO.
TB5,PIN 1
TB5,PIN 2
TB5,PIN 3
TB5,PIN 4
TB5,PIN 5
TB5,PIN 6
TB5,PIN 7
TB5,PIN 8
TB5,PIN 9
TB5,PIN 10
TB6,PIN 1
TB6,PIN 2
TB6,PIN 7
TB6,PIN 8
P2,PIN 1
P2,PIN 3
P2,PIN 4
P2,PIN 5
5-PIN AMPHENOL CONNECTOR ON BACK PANEL
25-PIN D-TYPE CONNECTOR
19"
7 3/8"
11/16"
BOXER FAN INSTALLATION AC TYPE
NOTE: HOOK-UP FOR AC POWER IS DIRECT TO +5V BATTERY BACK-UP POWER SUPPLY PINS 1 + 2 AND PINS 3 + 4 OF TRANSFORMER.
LAYOUT OF BACK DOOR
1"
18"
12"
LABEL TERMINAL POINTS AS SHOWN ABOVE ON RIGHT SIDE OF 8 POINT TERMINAL BLOCKS
TB2
TB3
TB4
TB5
TB6
RELAY 1
STANDARD 8 POINT TERMINAL BLOCK MOUNTED ON BACK SIDE OF DOOR
AMPHENOL 5-PIN CONNECTOR
P2
TOGGLE SWITCH
ALARM TEST
HINGE
1"
SCALE
2"
FRONT VIEW
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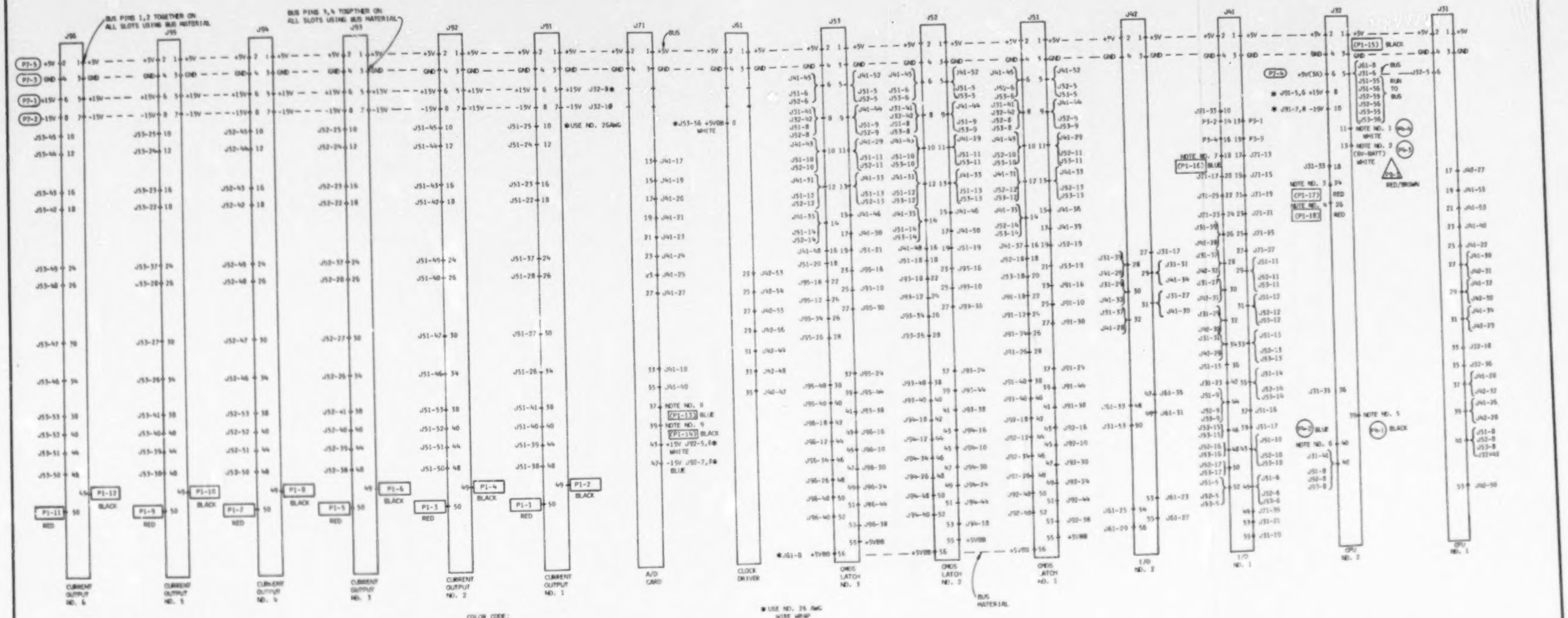
DIVISION OF RESEARCH
PLUGGING FACTOR MONITOR
ELECTRONIC CONTROLLER
BACKPANEL WIRING DIAGRAM
DESIGNED
TECHNICAL APPROVAL
DRAWN
SUBMITTED
CHECKED
APPROVED
DENVER, COLORADO
1292-PI-8

Figure 7.—Back panel wiring diagram.


BUS PINS 1,2 TOGETHER ON ALL SLOTS USING BUS MATERIAL
BUS PINS 3,4 TOGETHER ON ALL SLOTS USING BUS MATERIAL
J96
J95
J94
J93
J92
J91
J71
J61
J53
J52
J51
J42
J41
J32
J31
CURRENT OUTPUT NO. 6
CURRENT OUTPUT NO. 5
CURRENT OUTPUT NO. 4
CURRENT OUTPUT NO. 3
CURRENT OUTPUT NO. 2
CURRENT OUTPUT NO. 1
A/D CARD
CLOCK DRIVER
CMOS LATCH NO. 3
CMOS LATCH NO. 2
CMOS LATCH NO. 1
I/O NO. 2
I/O NO. 1
CPU NO. 2
CPU NO. 1
BUS MATERIAL
RUN TO BUS
* USE NO. 26 AWG WIRE WRAP

NOTES:
1. BATTERY BACKUP SWITCH - PANEL (P6 PIN 4)
2. BACKUP BATTERY 8V - 2.8 AH (P6 PIN 3) (P9-1)
3. MECHANICAL UNIT - LOW SENSOR
4. MECHANICAL UNIT - HIGH SENSOR
5. RESET SWITCH N.C. (LOW) - PANEL (P6 PIN 1)
6. RESET SWITCH N.O. (HIGH) - PANEL (P6 PIN 2)
7. MECHANICAL UNIT - PAPER FAULT DETECTOR
8. TRANSDUCER - HIGH - (+) (4-20MA)
9. TRANSDUCER - LOW - (-) (4-20MA)

▭ - INDICATION OF CONNECTION TO P1 (FEMALE) 25-PIN D-TYPE CONNECTOR. USE NO. 26 SOLID WIRE WRAP WIRE

COLOR CODE:

RED	+5V
WHITE	+5V CMOS (3A)
BLACK	GND
BLUE	-15V
WHITE/GREEN	+15V
RED/BROWN	+8V BATTERY

○ - INDICATION OF CONNECTION TO P6 (FEMALE) 5-PIN MOLEX CONNECTOR. USE NO. 26 SOLID WIRE WRAP WIRE.

⬭ - INDICATION OF CONNECTION TO P7 (MALE) 5-PIN MOLEX CONNECTOR (LARGE). USE NO. 16 OR BETTER STRANDED WIRE.

△ P9-1 - CONNECT J32-13 TO P9 (FEMALE) 1-PIN MOLEX CONNECTOR (LARGE). USE NO. 18 OR BETTER STRANDED WIRE.

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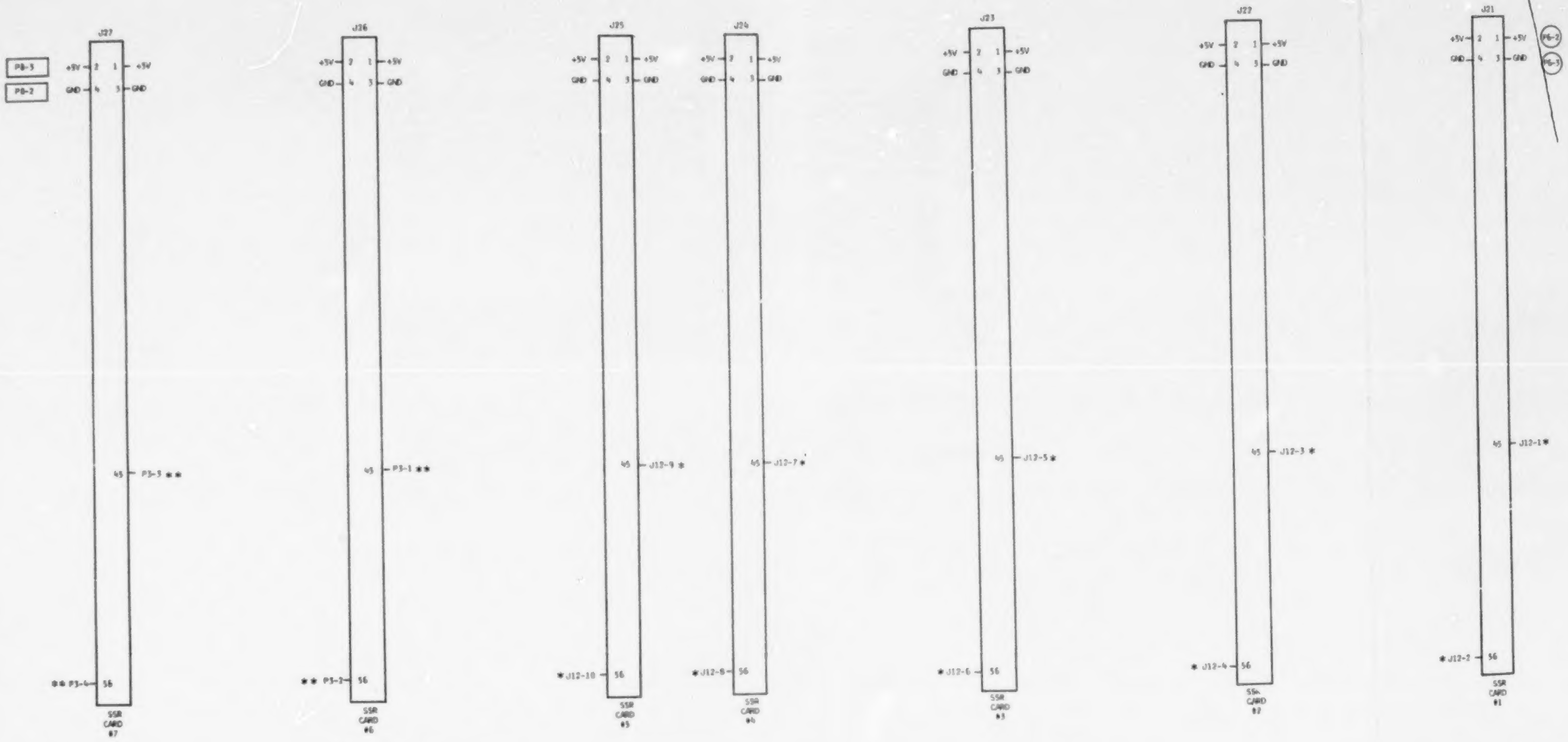
PLUGGING FACTOR MONITOR
ELECTRONIC CONTROLLER
BACKPLANE WIRING DIAGRAM
MAIN CARD FILE (PIN-VIEW)

DESIGNED [illegible] TECHNICAL APPROVAL [illegible]
DRAWN [illegible] SUBMITTED [illegible]
CHECKED [illegible] APPROVED [illegible]
DENVER, COLORADO
1292-PI-9

Figure 8.—Pin view of backplane wiring for main card file.


P8-3
P8-2
J27
+5V 2 1 +5V
GND 4 3 GND
45 P3-3 **
** P3-4 56
SSR CARD #7
J26
+5V 2 1 +5V
GND 4 3 GND
45 P3-1 **
** P3-2 56
SSR CARD #6
J25
+5V 2 1 +5V
GND 4 3 GND
45 J12-9 *
* J12-10 56
SSR CARD #5
J24
+5V 2 1 +5V
GND 4 3 GND
45 J12-7 *
* J12-8 56
SSR CARD #4
J23
+5V 2 1 +5V
GND 4 3 GND
45 J12-5 *
* J12-6 56
SSR CARD #3
J22
+5V 2 1 +5V
GND 4 3 GND
45 J12-3 *
* J12-4 56
SSR CARD #2
J21
+5V 2 1 +5V
GND 4 3 GND
P6-2
P6-1
45 J12-1 *
* J12-2 56
SSR CARD #1

NOTE:

** P3 - CONNECTOR BETWEEN J41 UPPER CARD FILE AND J26 AND J27 LOWER CARD FILE P3 IS A 5-PIN MOLEX CONNECOTR (FEMALE) USE NO. 28 AWG RIBBON CABLE.

* J12 IS 16-PIN DIP CONNECTOR ON I/O CARD NO. 1 SLOT J41 USE NO. 28 AWG RIBBON CABLE

COLOR CODE:

P3-1; J26-45 AND J41-13 (BROWN)
P3-2; J26-56 AND J41-14 (RED)
P3-3; J27-45 AND J41-15 (ORANGE)
P3-4; J27-56 AND J41-16 (YELLOW)

J12-1 AND J21-45 (RED)
J12-2 AND J21-56 (YELLOW)
J12-3 AND J22-45 (BLUE)
J12-4 AND J22-56 (GRAY)
J12-5 AND J23-45 (BLACK)
J12-6 AND J23-56 (RED)
J12-7 AND J24-45 (YELLOW)
J12-8 AND J24-56 (BLUE)
J12-9 AND J25-45 (GREEN)
J12-10 AND J25-56 (ORANGE)

+5V (RED)
GND (BLACK)

▭ — INDICATION OF CONNECTION TO P8 CONNECTOR (FEMALE), WHICH IS A 3-PIN MOLEX CONNECTOR (LARGE). USE NO. 18 OR BETTER STRANDED WIRE.

○ — INDICATION OF CONNECTION TO P6 CONNECTOR (FEMALE), WHICH IS A 3-PIN MOLEX CONNECTOR (SMALL). USE NO. 20 OR BETTER STRANDED WIRE.

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DIVISION OF RESEARCH
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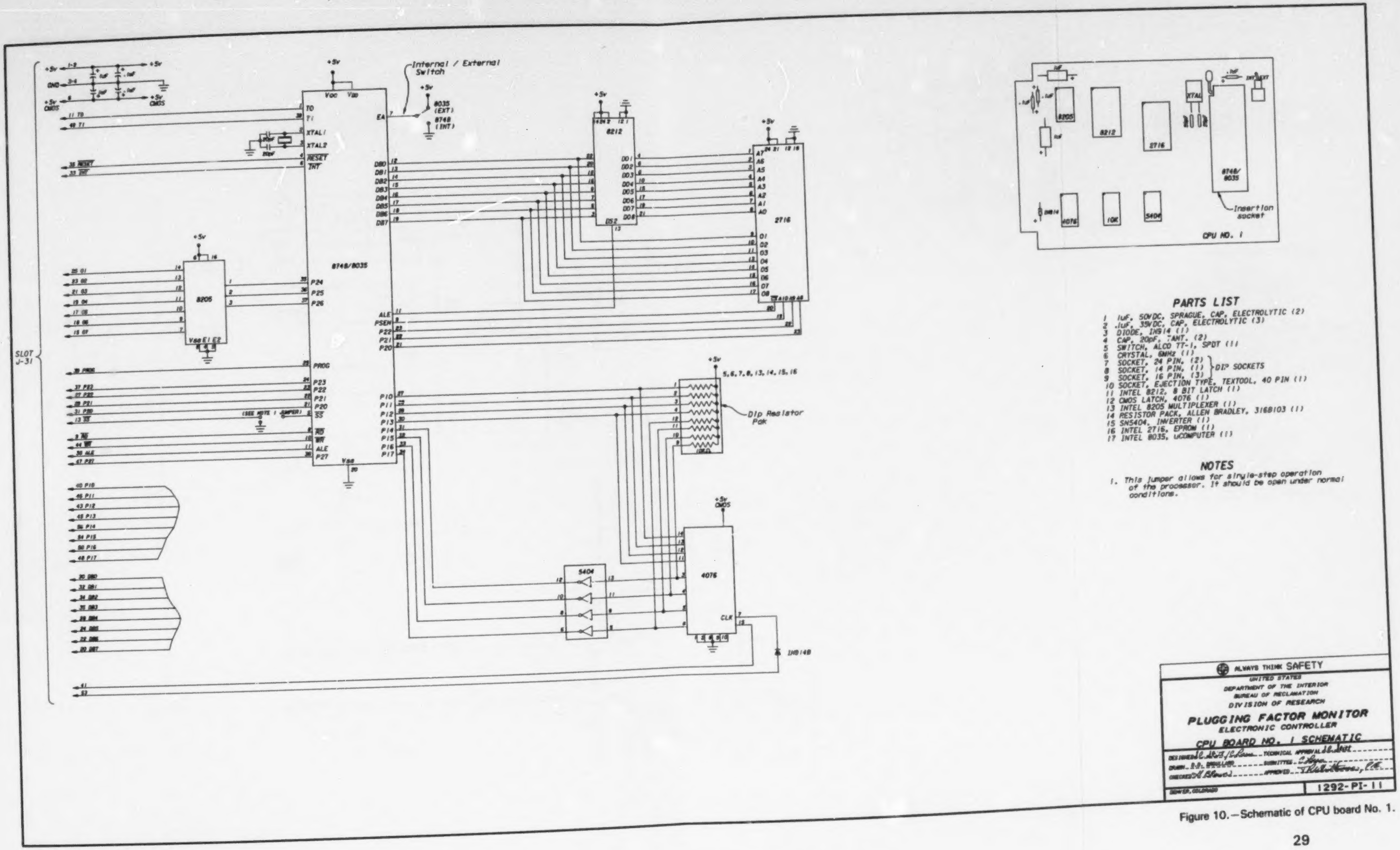
ELECTRONIC CONTROLLER
BACKPLANE WIRING DIAGRAM
SSR CARD FILE
(PIN-VIEW)

DESIGNED ____ TECHNICAL APPROVAL ____
DRAWN ____ SUBMITTED ____
CHECKED ____ APPROVED ____
DENVER, COLORADO
1292-PI-10

Figure 9.—Pin view of backplane wiring for SSR card file.


+5v
GND
+5v CMOS
SLOT J-31
8748/8035
Vcc
Vdd
Vss
T0
T1
XTAL1
XTAL2
RESET
INT
EA
DB0
DB1
DB2
DB3
DB4
DB5
DB6
DB7
P24
P25
P26
ALE
PSEN
P22
P21
P20
PROG
P23
SS
RD
WR
P27
P10
P11
P12
P13
P14
P15
P16
P17
Internal / External Switch
8035 (EXT)
8748 (INT)
8212
DS2
8205
2716
(SEE NOTE 1 JUMPER)
Dip Resistor Pak
5404
4076
CLK
1N914B
CPU NO. 1
Insertion socket
XTAL
INT/EXT

PARTS LIST

1 1uF, 50VDC, SPRAGUE, CAP, ELECTROLYTIC (2)
2 .1uF, 35VDC, CAP, ELECTROLYTIC (3)
3 DIODE, 1N914 (1)
4 CAP, 20pF, TANT. (2)
5 SWITCH, ALCO TT-1, SPDT (1)
6 CRYSTAL, 6MHz (1)
7 SOCKET, 24 PIN, (2) } DIP SOCKETS
8 SOCKET, 14 PIN, (1)
9 SOCKET, 16 PIN, (3)
10 SOCKET, EJECTION TYPE, TEXTOOL, 40 PIN (1)
11 INTEL 8212, 8 BIT LATCH (1)
12 CMOS LATCH, 4076 (1)
13 INTEL 8205 MULTIPLEXER (1)
14 RESISTOR PACK, ALLEN BRADLEY, 316B103 (1)
15 SN5404, INVERTER (1)
16 INTEL 2716, EPROM (1)
17 INTEL 8035, uCOMPUTER (1)

NOTES

1. This jumper allows for single-step operation of the processor. It should be open under normal conditions.

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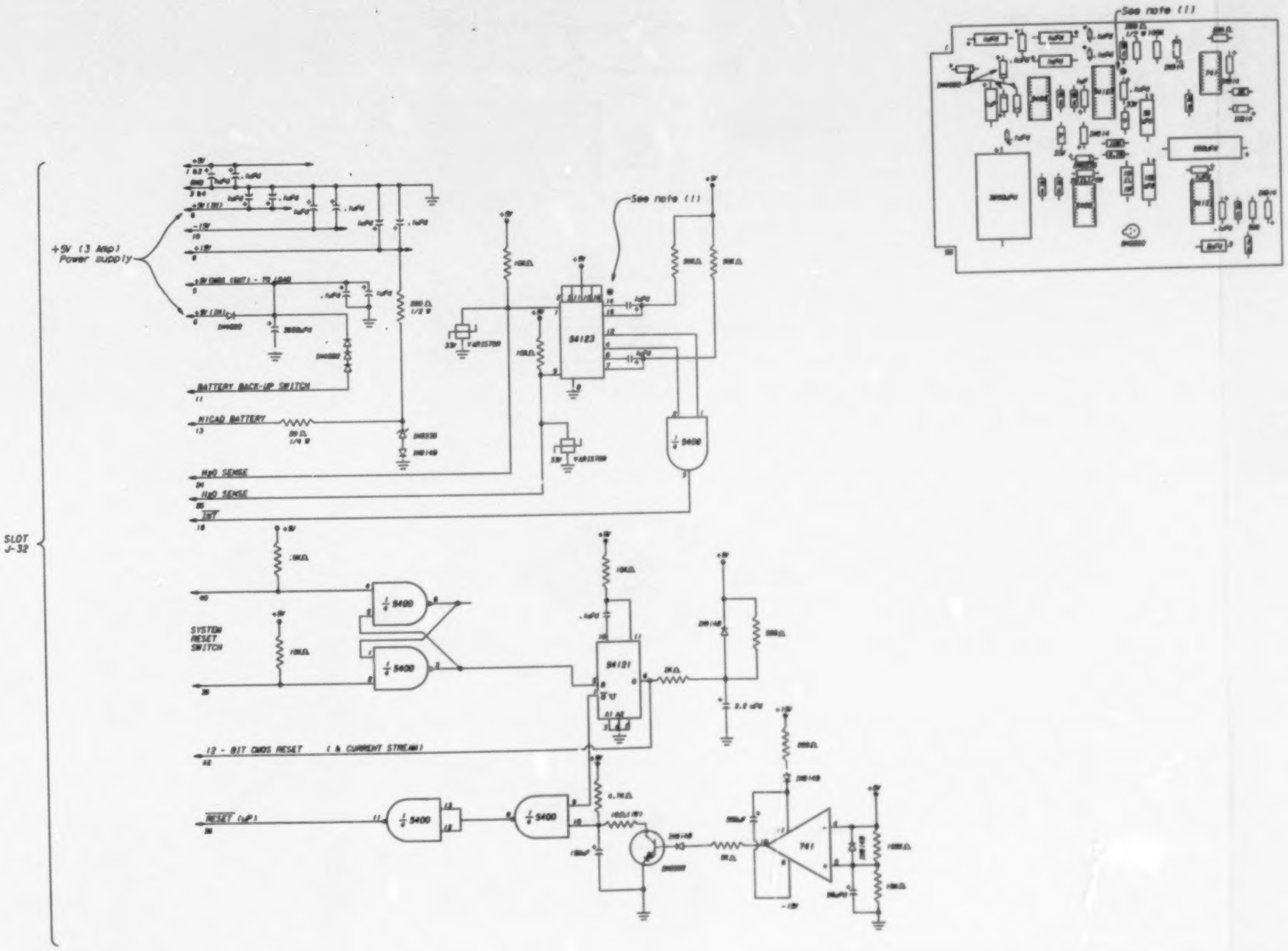
PLUGGING FACTOR MONITOR
ELECTRONIC CONTROLLER
CPU BOARD NO. 1 SCHEMATIC

DESIGNED ______ TECHNICAL APPROVAL ______
DRAWN ______ SUBMITTED ______
CHECKED ______ APPROVED ______
DENVER, COLORADO
1292-PI-11

Figure 10.—Schematic of CPU board No. 1.



See note (1)
+5V (3 Amp) Power supply
SLOT J-32
BATTERY BACK-UP SWITCH
NICAD BATTERY
H2O SENSE
INT
54123
1/2 5408
33V VARISTOR
SYSTEM RESET SWITCH
1/2 5400
54121
12 - BIT CMOS RESET (& CURRENT STREAM)
RESET (µP)
741

NOTES

1. A correction to the printed circuit board must be made at this point. The plus side of the .1uF cap should be jumpered to the 50K resistor. The PCB foil between the minus side of the this cap and the 50K resistor should be broken.

COMPONENT LISTING

1. 741 OP Amp (1)
2. 5400 Quad Nand (1)
3. 5408 Quad and Gate (1)
4. 54121 One - Shot (1)
5. 54123 Dual One - Shot (1)
6. IN4148 Diodes (5)
7. IN4002 Diodes (4)
8. IN5235 Zener Diode (1)
9. 1uFd Capacitors (50VDC) Sprague (4)
10. .1uFd Capacitors (6)
11. 3600uFd Capacitor Battery (15V) (1)
12. 150uFd Capacitor (1)
13. 56uFd Capacitor (1)
14. 250uFd Capacitor (CDE - 50VDC) (1)
15. 2.2uFd Capacitor (1)
16. 2N2222 Transistor (1)
17. 10KΩ Resistors (5)
18. 50KΩ Resistors (2)
19. 10Ω(1W) Resistor (1)
20. 4.7KΩ Resistor (1)
21. 200Ω Resistor (1)
22. 500Ω Resistor (1)
23. 200Ω(1/2W) Resistor (1)
24. 10MEGΩ Resistor (1)
25. 2KΩ Resistor (2)
26. 100KΩ Resistor (1)
27. 33V Varistor (33Z1 - GE[illegible]) (2)
28. 1uFd Capacitors (DISC) (2)
29. Socket, 16 Pin Dip (1)
30. Socket, 14 Pin Dip (4)
31. Socket, 3 Pin Transistor (1)

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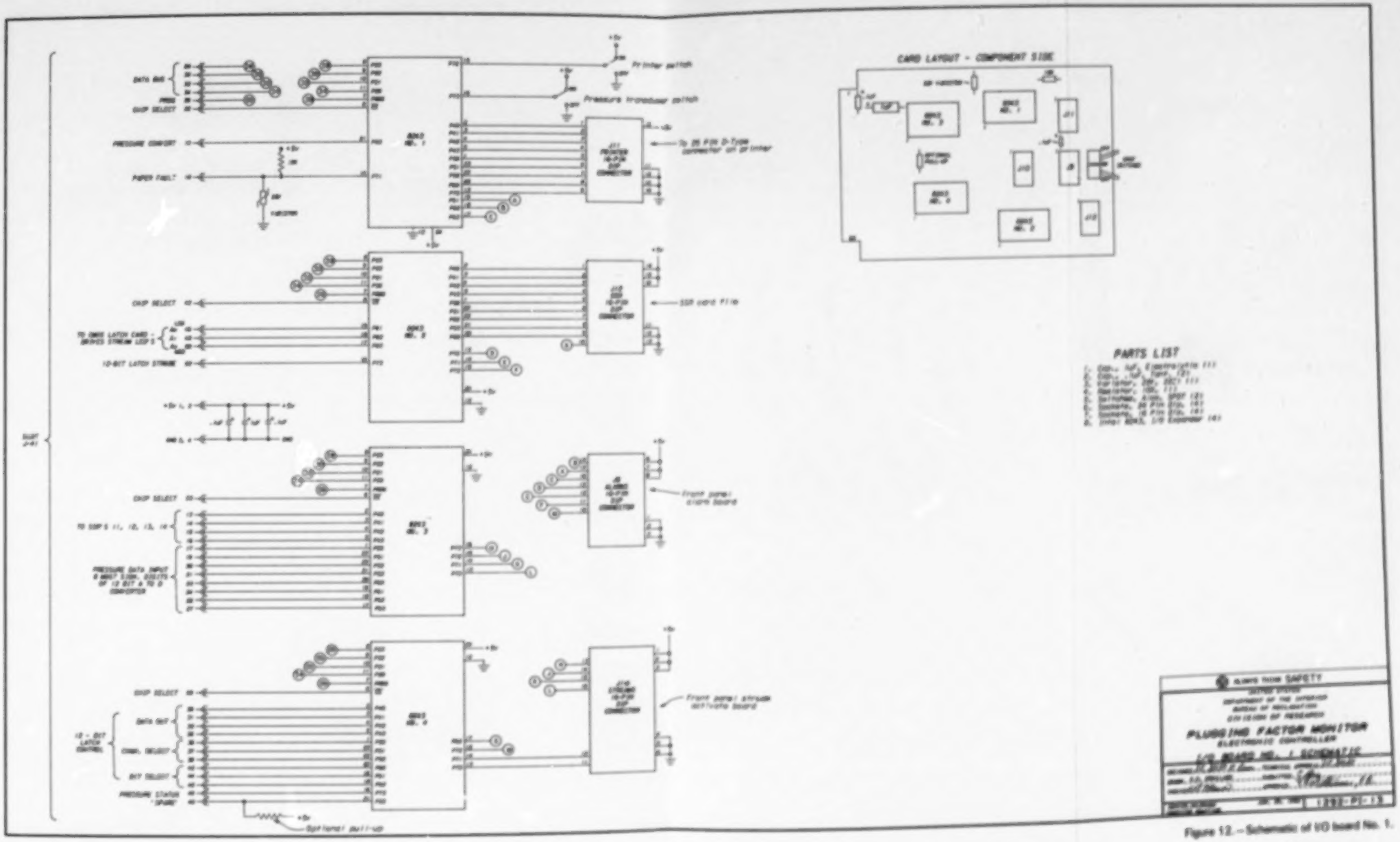
CPU BOARD NO. 2 SCHEMATIC
1292-PI-12

Figure 11.—Schematic of CPU board No. 2.


DATA BUS
CHIP SELECT
PRESSURE CONVERT
PAPER FAULT
Printer switch
Pressure transducer switch
8243 NO. 1
8243 NO. 2
8243 NO. 3
8243 NO. 4
To 25 Pin D-Type connector on printer
SSR card file
12-BIT LATCH STROBE
TO SDP'S 11, 12, 13, 14
PRESSURE DATA INPUT
Front panel alarm board
Front panel strobe activate board
12 - BIT LATCH CONTROL
DATA OUT
CHAN. SELECT
BIT SELECT
PRESSURE STATUS
"SPARE"
Optional pull-up
CARD LAYOUT - COMPONENT SIDE
PARTS LIST
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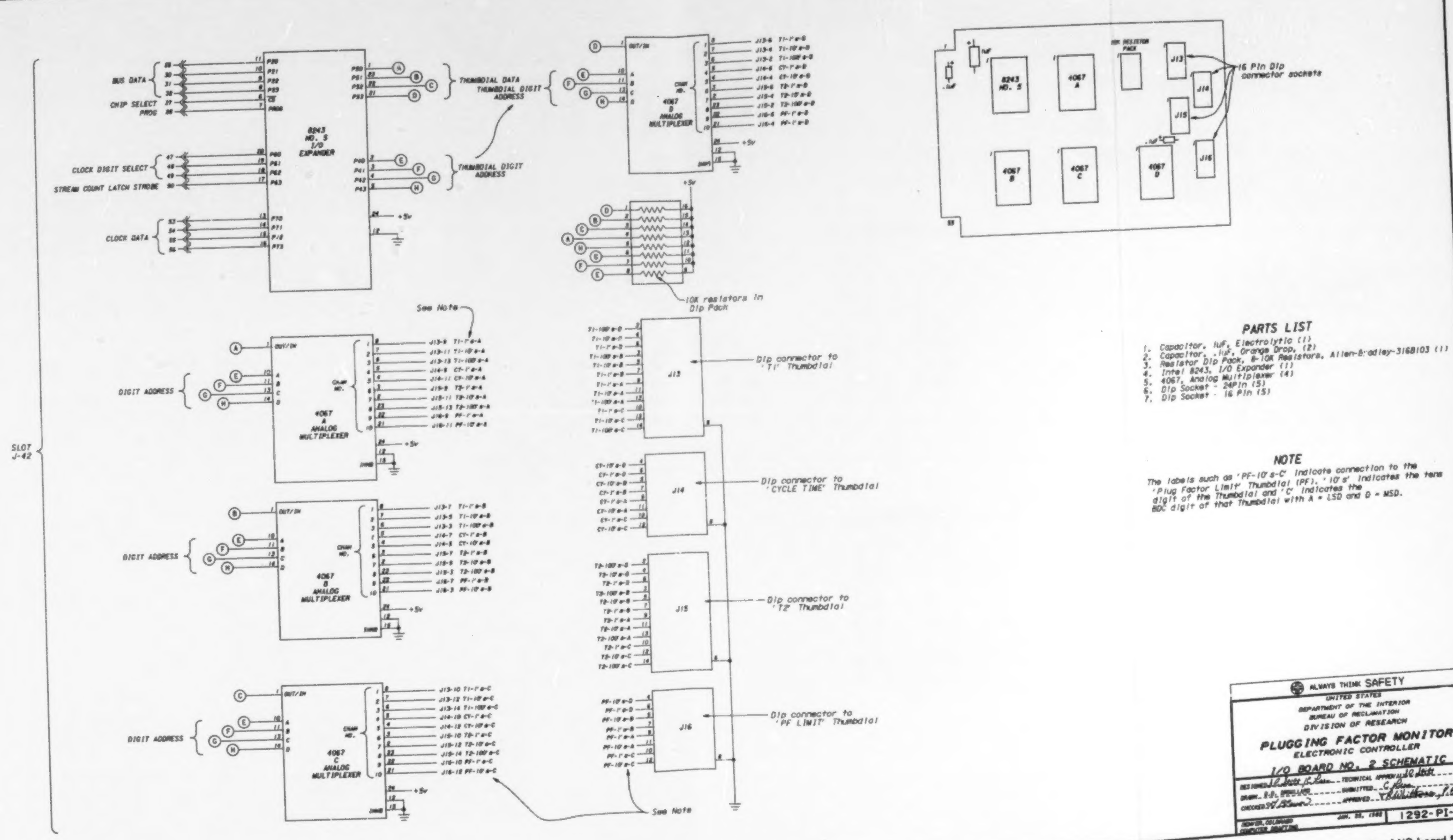
PLUGGING FACTOR MONITOR
ELECTRONIC CONTROLLER
I/O BOARD NO. 1 SCHEMATIC

Figure 12.—Schematic of I/O board No. 1.


BUS DATA
CHIP SELECT
PROG
CLOCK DIGIT SELECT
STREAM COUNT LATCH STROBE
CLOCK DATA
8243 NO. 5 I/O EXPANDER
THUMBDIAL DATA
THUMBDIAL DIGIT ADDRESS
+5v
SLOT J-42
DIGIT ADDRESS
4067 A ANALOG MULTIPLEXER
4067 B ANALOG MULTIPLEXER
4067 C ANALOG MULTIPLEXER
4067 D ANALOG MULTIPLEXER
CHAN NO.
OUT/IN
See Note
10K resistors in Dip Pack
J13
J14
J15
J16
Dip connector to 'T1' Thumbdial
Dip connector to 'CYCLE TIME' Thumbdial
Dip connector to 'T2' Thumbdial
Dip connector to 'PF LIMIT' Thumbdial
10K RESISTOR PACK
8243 NO. 5
4067 A
4067 B
4067 C
4067 D
16 Pin Dip connector sockets
.1uF
1uF

PARTS LIST

1. Capacitor, 1uF, Electrolytic (1)
2. Capacitor, .1uF, Orange Drop, (2)
3. Resistor Dip Pack, 8-10K Resistors, Allen-Bradley-316B103 (1)
4. Intel 8243, I/O Expander (1)
5. 4067, Analog Multiplexer (4)
6. Dip Socket - 24Pin (5)
7. Dip Socket - 16 Pin (5)

NOTE

The labels such as 'PF-10's-C' indicate connection to the 'Plug Factor Limit' Thumbdial (PF), '10's' indicates the tens digit of the Thumbdial and 'C' indicates the BDC digit of that Thumbdial with A = LSD and D = MSD.

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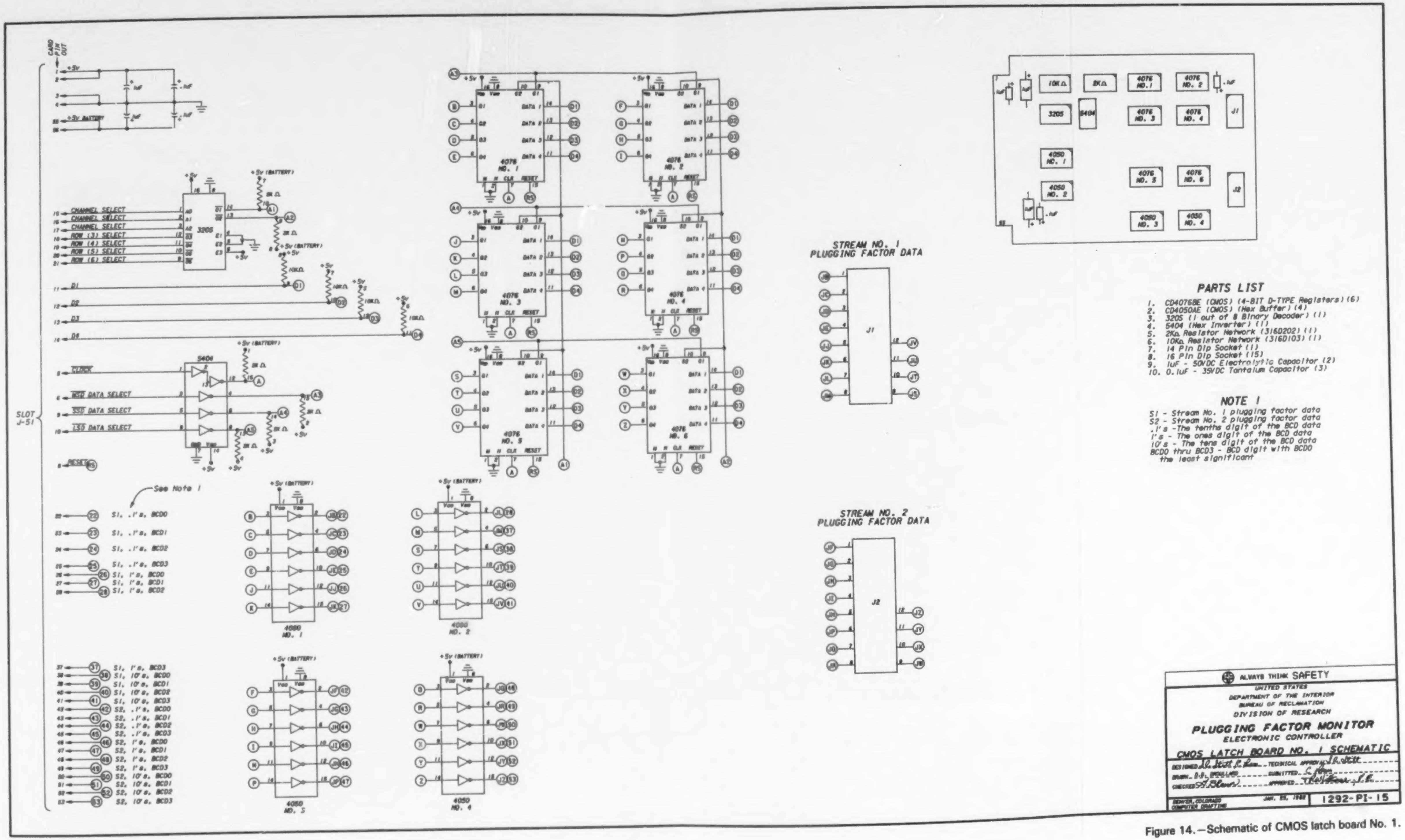
PLUGGING FACTOR MONITOR
ELECTRONIC CONTROLLER
I/O BOARD NO. 2 SCHEMATIC

DESIGNED _______ TECHNICAL APPROVAL _______
DRAWN _______ SUBMITTED C. _______
CHECKED _______ APPROVED _______, P.E.

DENVER, COLORADO
JAN. 25, 1982
1292-PI-14

Figure 13.—Schematic of I/O board No. 2.


CARD PIN OUT
SLOT J-51
CHANNEL SELECT
ROW (3) SELECT
ROW (4) SELECT
ROW (5) SELECT
ROW (6) SELECT
3205
5404
CLOCK
MSD DATA SELECT
SSD DATA SELECT
LSD DATA SELECT
RESET
+5v (BATTERY)
4076 NO. 1
4076 NO. 2
4076 NO. 3
4076 NO. 4
4076 NO. 5
4076 NO. 6
4050 NO. 1
4050 NO. 2
4050 NO. 3
4050 NO. 4
See Note 1
STREAM NO. 1 PLUGGING FACTOR DATA
J1
STREAM NO. 2 PLUGGING FACTOR DATA
J2
10KΩ
2KΩ

PARTS LIST

1. CD4076BE (CMOS) (4-BIT D-TYPE Registers) (6)
2. CD4050AE (CMOS) (Hex Buffer) (4)
3. 3205 (1 out of 8 Binary Decoder) (1)
4. 5404 (Hex Inverter) (1)
5. 2KΩ Resistor Network (316D202) (1)
6. 10KΩ Resistor Network (316D103) (1)
7. 14 Pin Dip Socket (1)
8. 16 Pin Dip Socket (15)
9. 1uF - 50VDC Electrolytic Capacitor (2)
10. 0.1uF - 35VDC Tantalum Capacitor (3)

NOTE 1

S1 - Stream No. 1 plugging factor data
S2 - Stream No. 2 plugging factor data
.1's -The tenths digit of the BCD data
1's - The ones digit of the BCD data
10's - The tens digit of the BCD data
BCD0 thru BCD3 - BCD digit with BCD0
the least significant

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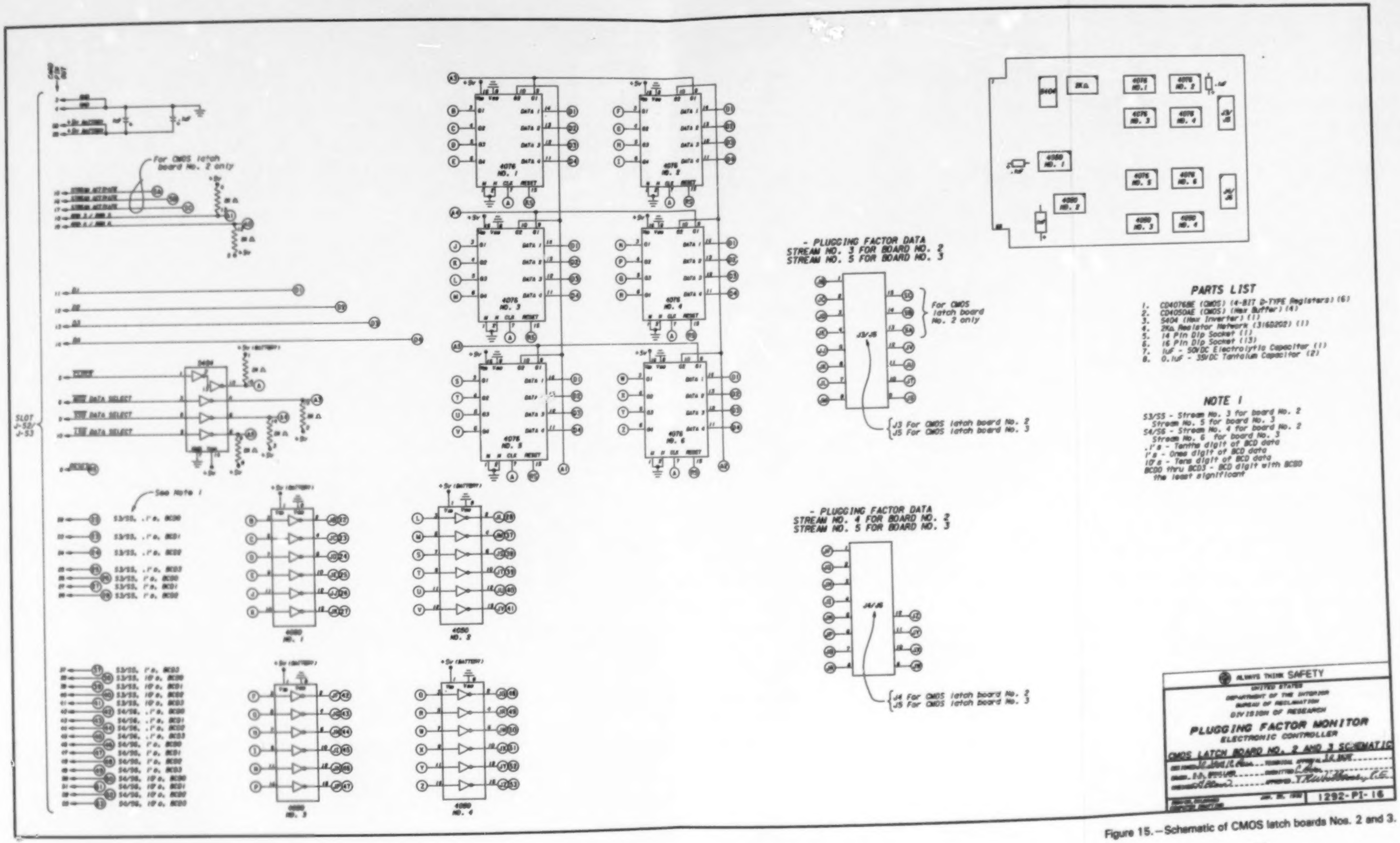
DIVISION OF RESEARCH
PLUGGING FACTOR MONITOR
ELECTRONIC CONTROLLER
CMOS LATCH BOARD NO. 1 SCHEMATIC
DESIGNED ____ TECHNICAL APPROVAL ____
DRAWN D.B. GROULARD ____ SUBMITTED ____
CHECKED ____ APPROVED ____
DENVER, COLORADO
COMPUTER DRAFTING
JAN. 25, 1982
1292-PI-15

Figure 14.—Schematic of CMOS latch board No. 1.


- PLUGGING FACTOR DATA
STREAM NO. 3 FOR BOARD NO. 2
STREAM NO. 5 FOR BOARD NO. 3
For CMOS latch board No. 2 only
J3/J5
J3 For CMOS latch board No. 2
J5 For CMOS latch board No. 3
- PLUGGING FACTOR DATA
STREAM NO. 4 FOR BOARD NO. 2
STREAM NO. 5 FOR BOARD NO. 3
J4/J6
J4 For CMOS latch board No. 2
J5 For CMOS latch board No. 3
4076 NO. 1
4076 NO. 2
4076 NO. 3
4076 NO. 4
4076 NO. 5
4076 NO. 6
4050 NO. 1
4050 NO. 2
4050 NO. 3
4050 NO. 4
5404
2KΩ
For CMOS latch board No. 2 only
See Note 1
SLOT J-52/J-53
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DIVISION OF RESEARCH
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ELECTRONIC CONTROLLER
CMOS LATCH BOARD NO. 2 AND 3 SCHEMATIC
1292-PI-16

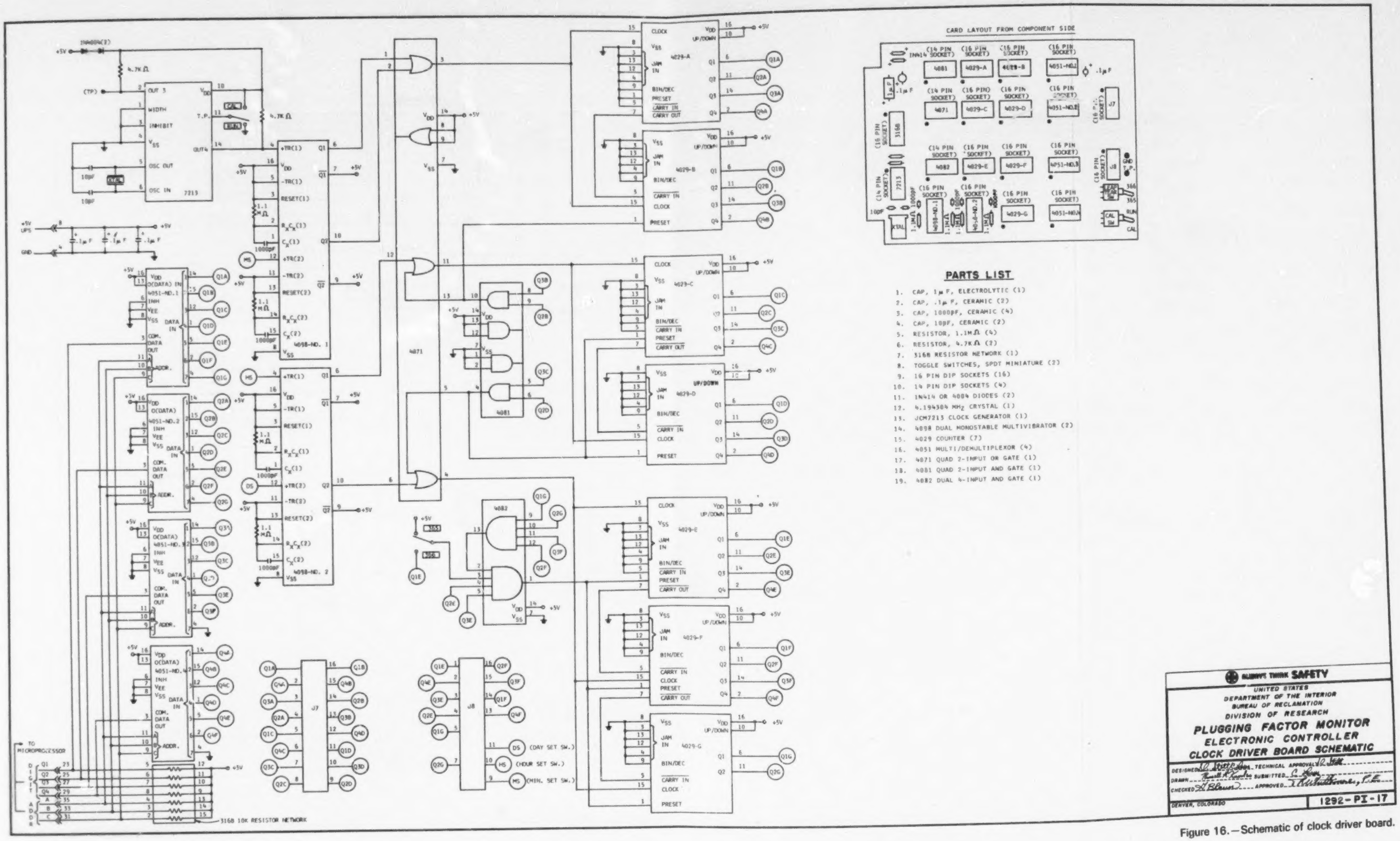
PARTS LIST

1. CD4076BE (CMOS) (4-BIT D-TYPE Registers) (6)
2. CD4050AE (CMOS) (Hex Buffer) (4)
3. 5404 (Hex Inverter) (1)
4. 2KΩ Resistor Network (316D202) (1)
5. 14 Pin Dip Socket (1)
6. 16 Pin Dip Socket (13)
7. 1uF - 50VDC Electrolytic Capacitor (1)
8. 0.1uF - 35VDC Tantalum Capacitor (2)

NOTE 1

S3/S5 - Stream No. 3 for board No. 2
Stream No. 5 for board No. 3
S4/S6 - Stream No. 4 for board No. 2
Stream No. 6 for board No. 3
.1's - Tenths digit of BCD data
1's - Ones digit of BCD data
10's - Tens digit of BCD data
BCD0 thru BCD3 - BCD digit with BCD0 the least significant

Figure 15.—Schematic of CMOS latch boards Nos. 2 and 3.


CARD LAYOUT FROM COMPONENT SIDE
7213
4098-NO. 1
4098-NO. 2
4071
4081
4082
4029-A
4029-B
4029-C
4029-D
4029-E
4029-F
4029-G
4051-NO.1
4051-NO.2
4051-NO.3
4051-NO.4
J7
J8
3168
XTAL
CAL
RUN
365
366
TO MICROPROCESSOR
DATA
ADDR
3168 10K RESISTOR NETWORK
DS (DAY SET SW.)
HS (HOUR SET SW.)
MS (MIN. SET SW.)
+5V
GND
1N4004(2)
4.7K Ω
1.1 MΩ
1000pF
10pF
.1µF
1µF

PARTS LIST

1. CAP, 1µF, ELECTROLYTIC (1)
2. CAP, .1µF, CERAMIC (2)
3. CAP, 1000pF, CERAMIC (4)
4. CAP, 10pF, CERAMIC (2)
5. RESISTOR, 1.1MΩ (4)
6. RESISTOR, 4.7KΩ (2)
7. 3168 RESISTOR NETWORK (1)
8. TOGGLE SWITCHES, SPDT MINIATURE (2)
9. 16 PIN DIP SOCKETS (16)
10. 14 PIN DIP SOCKETS (4)
11. 1N414 OR 4004 DIODES (2)
12. 4.194304 MHz CRYSTAL (1)
13. JCM7213 CLOCK GENERATOR (1)
14. 4098 DUAL MONOSTABLE MULTIVIBRATOR (2)
15. 4029 COUNTER (7)
16. 4051 MULTI/DEMULTIPLEXOR (4)
17. 4071 QUAD 2-INPUT OR GATE (1)
18. 4081 QUAD 2-INPUT AND GATE (1)
19. 4082 DUAL 4-INPUT AND GATE (1)

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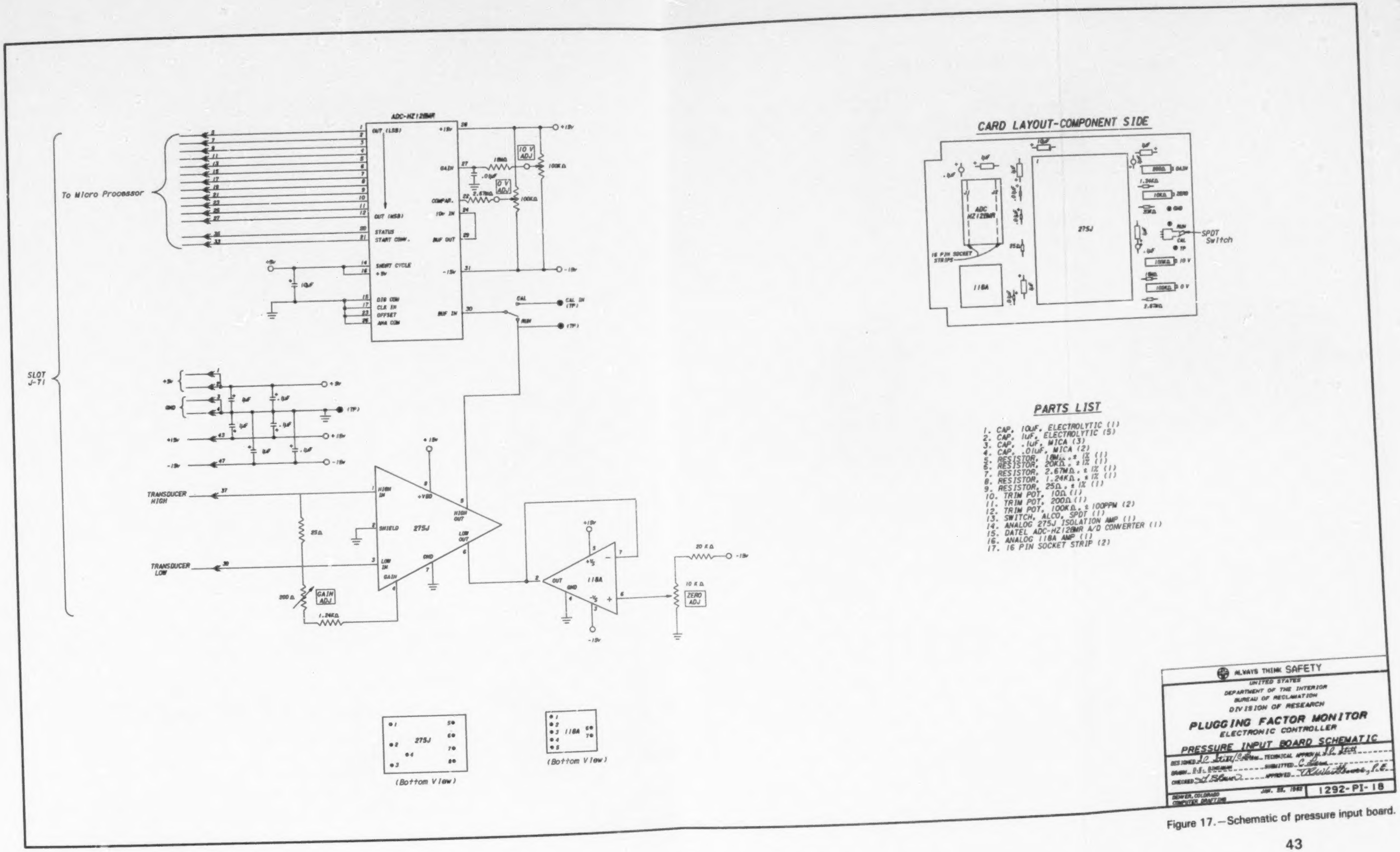
DIVISION OF RESEARCH

PLUGGING FACTOR MONITOR
ELECTRONIC CONTROLLER
CLOCK DRIVER BOARD SCHEMATIC

DESIGNED .... TECHNICAL APPROVAL ....
DRAWN .... SUBMITTED ....
CHECKED .... APPROVED ....
DENVER, COLORADO
1292-PI-17

Figure 16.—Schematic of clock driver board.


ADC-HZ12BMR
OUT (LSB)
OUT (MSB)
STATUS
START CONV.
SHORT CYCLE
DIG COM
CLK IN
OFFSET
ANA COM
+15v
GAIN
COMPAR.
10v IN
BUF OUT
-15v
BUF IN
To Micro Processor
SLOT J-71
10 V ADJ
0 V ADJ
100KΩ
2.67MΩ
.01µF
10µF
CAL
RUN
CAL IN (TP)
(TP)
+5v
GND
+15v
-15v
TRANSDUCER HIGH
TRANSDUCER LOW
HIGH IN
SHIELD
LOW IN
GAIN
+VISO
HIGH OUT
LOW OUT
GND
275J
25Ω
200Ω
GAIN ADJ
1.24KΩ
OUT
118A
20 KΩ
10 KΩ
ZERO ADJ
(Bottom View)
CARD LAYOUT-COMPONENT SIDE
ADC HZ12BMR
16 PIN SOCKET STRIPS
SPDT Switch
RUN
CAL
TP
10 V
0 V
ZERO
GAIN
GND

PARTS LIST

1. CAP, 10uF, ELECTROLYTIC (1)
2. CAP, 1uF, ELECTROLYTIC (5)
3. CAP, .1uF, MICA (3)
4. CAP, .01uF, MICA (2)
5. RESISTOR, 18MΩ, ± 1% (1)
6. RESISTOR, 20KΩ, ± 1% (1)
7. RESISTOR, 2.67MΩ, ± 1% (1)
8. RESISTOR, 1.24KΩ, ± 1% (1)
9. RESISTOR, 25Ω, ± 1% (1)
10. TRIM POT, 10Ω (1)
11. TRIM POT, 200Ω (1)
12. TRIM POT, 100KΩ, ± 100PPM (2)
13. SWITCH, ALCO, SPDT (1)
14. ANALOG 275J ISOLATION AMP (1)
15. DATEL ADC-HZ12BMR A/D CONVERTER (1)
16. ANALOG 118A AMP (1)
17. 16 PIN SOCKET STRIP (2)

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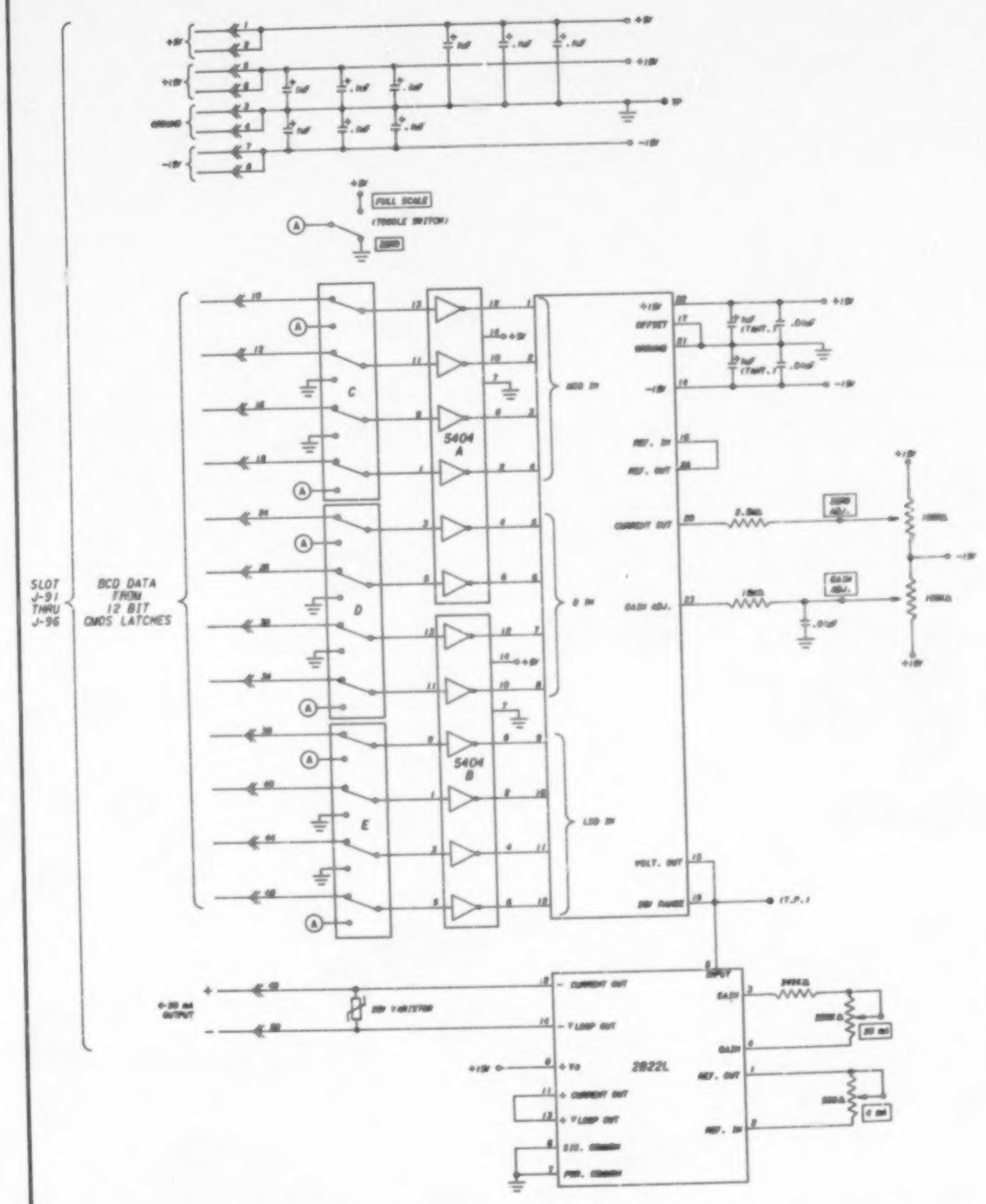
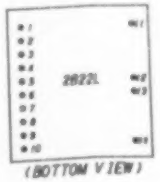
DIVISION OF RESEARCH
PLUGGING FACTOR MONITOR
ELECTRONIC CONTROLLER
PRESSURE INPUT BOARD SCHEMATIC
DESIGNED ______ TECHNICAL APPROVAL ______
DRAWN ______ SUBMITTED ______
CHECKED ______ APPROVED ______, P.E.
DENVER, COLORADO
COMPUTER DRAFTING
JAN. 22, 1982
1292-PI-18

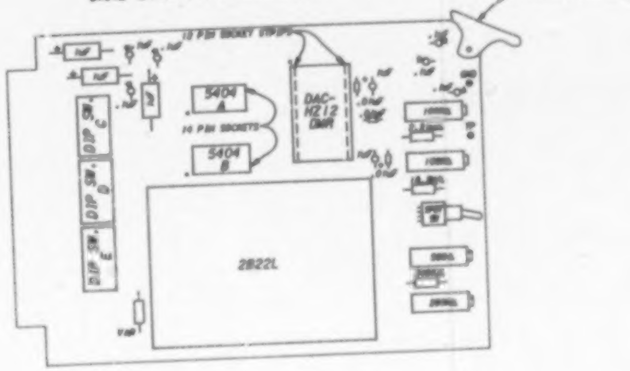
Figure 17.—Schematic of pressure input board.


+5V
+15V
GROUND
-15V
FULL SCALE
(TOGGLE SWITCH)
ZERO
SLOT J-91 THRU J-96
BCD DATA FROM 12 BIT CMOS LATCHES
C
D
E
5404 A
5404 B
MSD IN
LSD IN
OFFSET
GROUND
REF. IN
REF. OUT
CURRENT OUT
GAIN ADJ.
VOLT. OUT
ZERO ADJ.
GAIN ADJ.
T.P.1
4-20 mA OUTPUT
22V VARISTOR
CURRENT OUT
V LOOP OUT
INPUT
GAIN
REF. OUT
REF. IN
SIG. COMMON
PWR. COMMON
2822L
20 mA
4 mA



(BOTTOM VIEW)

CARD LAYOUT FROM COMPONENT SIDE


Card ejector
12 PIN SOCKET STRIPS
5404 A
5404 B
14 PIN SOCKETS
DAC-HZ12 DMR
DIP SW. C
DIP SW. D
DIP SW. E
2822L

PARTS LIST

1. Cap. 1uF, Electrolytic (3)
2. Cap. 1uF, Tantalum (2)
3. Cap. .1uF, Disc (6)
4. Cap. .01uF, Disc (3)
5. Resistor, 10MΩ ±1% (1)
6. Resistor, 2.2MΩ ±1% (1)
7. Resistor, 249KΩ ±1% (1)
8. Trim Pot, 250KΩ (1)
9. Trim Pot, 100KΩ (2)
10. Trim Pot, 500Ω (1)
11. Varistor, 22V (1)
12. Dip switches, 4 SPDT (3)
13. Toggle Switch, Miniature SPDT (1)
14. Analog 2822L Voltage/Isolated current converter (1)
15. DM5404 Hex Inverters (2)
16. 14 Pin Dip Sockets (2)
17. Datel Dac-HZ12DMR D/A Converter (1)
18. 12 Pin Socket Strips (2)

CALIBRATION PROCEDURES

1. Place 12 dip switches to the "CALIBRATE" position.
2. Connect a voltmeter to "TP" and "GND" connections.
3. Place toggle switch to the "ZERO" position.
4. Adjust "ZERO POTENTIOMETER" for 0.00 volts output.
5. Place toggle switch to the "FULL SCALE" position.
6. Adjust "GAIN POTENTIOMETER" for +9.995 volts output.
7. Install a 499 OHM resistor across current output terminals
8. Connect a voltmeter across the 499 OHM resistor.
9. Place toggle switch to the "ZERO " position.
10. Adjust "4ma POTENTIOMETER" to +2.00 volts output.
11. Place toggle switch to the "FULL SCALE" position.
12. Adjust "20ma POTENTIOMETER" for +10.00 volts output.
13. Repeat steps 9 thru 12 to verify calibration.
14. Disconnect test equipment.
15. Place 12 dip switches to the "RUN" position.

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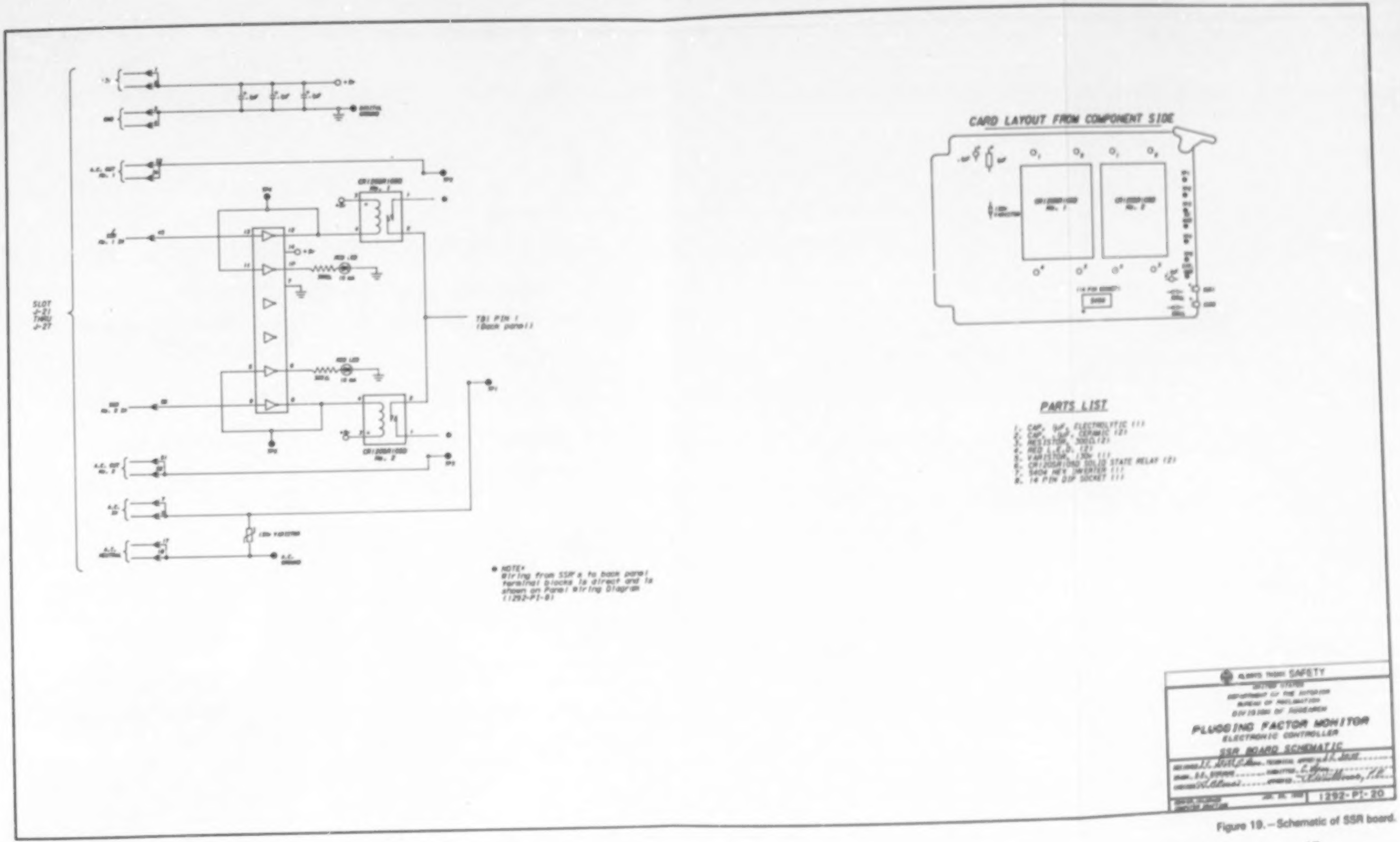
PLUGGING FACTOR MONITOR
ELECTRONIC CONTROLLER
CURRENT OUTPUT BOARD SCHEMATIC

1292-PI-19

Figure 18.—Schematic of current output board.


+5v
GND
A.C. OUT No. 1
A.C. OUT No. 2
A.C. IN
A.C. NEUTRAL
A.C. GROUND
SLOT J-21 THRU J-27
CR1200R1050 No. 1
CR1200R1050 No. 2
RED LED
10 mA
390Ω
TB1 PIN 1 (Back panel)
130v VARISTOR
TP1
TP2
TP3
● NOTE:
Wiring from SSR's to back panel terminal blocks is direct and is shown on Panel Wiring Diagram (1292-PT-8)
CARD LAYOUT FROM COMPONENT SIDE
14 PIN SOCKET
PARTS LIST
1. CAP. 5uF, ELECTROLYTIC (1)
2. CAP. .1uF, CERAMIC (2)
3. RESISTOR, 390Ω (2)
4. RED L.E.D. (2)
5. VARISTOR, 130v (1)
6. CR1200R1050 SOLID STATE RELAY (2)
7. 5404 HEX INVERTER (1)
8. 14 PIN DIP SOCKET (1)
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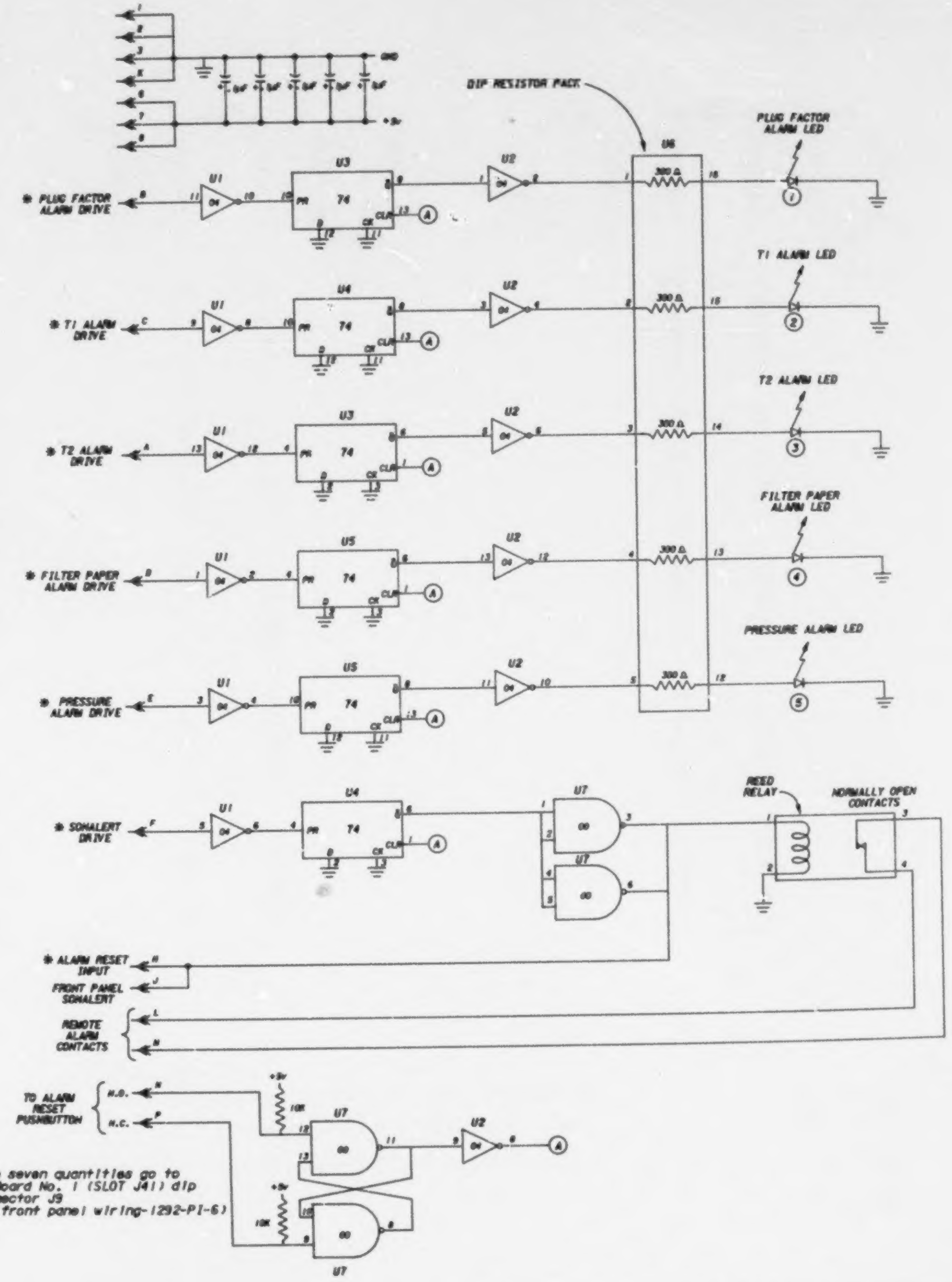
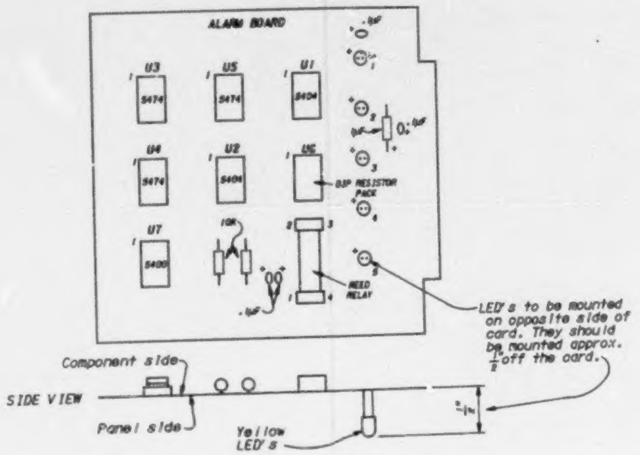
PLUGGING FACTOR MONITOR
ELECTRONIC CONTROLLER
SSR BOARD SCHEMATIC
1292-PT-20

Figure 19.—Schematic of SSR board.


1
2
3
X
6
7
8
GND
+5v
1µF
DIP RESISTOR PACK
U6
PLUG FACTOR ALARM LED
T1 ALARM LED
T2 ALARM LED
FILTER PAPER ALARM LED
PRESSURE ALARM LED
300 Ω
* PLUG FACTOR ALARM DRIVE
* T1 ALARM DRIVE
* T2 ALARM DRIVE
* FILTER PAPER ALARM DRIVE
* PRESSURE ALARM DRIVE
* SONALERT DRIVE
U1
U2
U3
U4
U5
U7
04
74
00
PR
D
CK
CLR
A
REED RELAY
NORMALLY OPEN CONTACTS
* ALARM RESET INPUT
FRONT PANEL SONALERT
REMOTE ALARM CONTACTS
TO ALARM RESET PUSHBUTTON
N.O.
N.C.
10K

*These seven quantities go to I/O Board No. 1 (SLOT J41) dip connector J9 (See front panel wiring-1292-PI-6)


ALARM BOARD
U3
U5
U1
U4
U2
U6
U7
5474
5404
5400
DIP RESISTOR PACK
10K
.1µF
REED RELAY
Component side
SIDE VIEW
Panel side
Yellow LED's

LED's to be mounted on opposite side of card. They should be mounted approx. 1/2" off the card.

PARTS LIST

1. IC, DUAL D-TYPE FLIP-FLOP, 5474 (3)
2. IC, QUAD NAND GATE, 5400 (1)
3. IC, HEX INVERTER, 5404 (2)
4. DIP RESISTOR PACK, 300Ω, ALLEN BRADLEY 316B301 (1)
5. REED RELAY, ELECTROL-RA30651051 (1)
6. RESISTOR, 10K(1/4W), (2)
7. CAPACITOR, .1µF (35v), (4)
8. CAPACITOR, 1µF-50v, (1)
9. LED-YELLOW, HP-5082-4555 (5)
10. SOCKET, DIP-14 PIN (6)
11. SOCKET, DIP-16 PIN (1)

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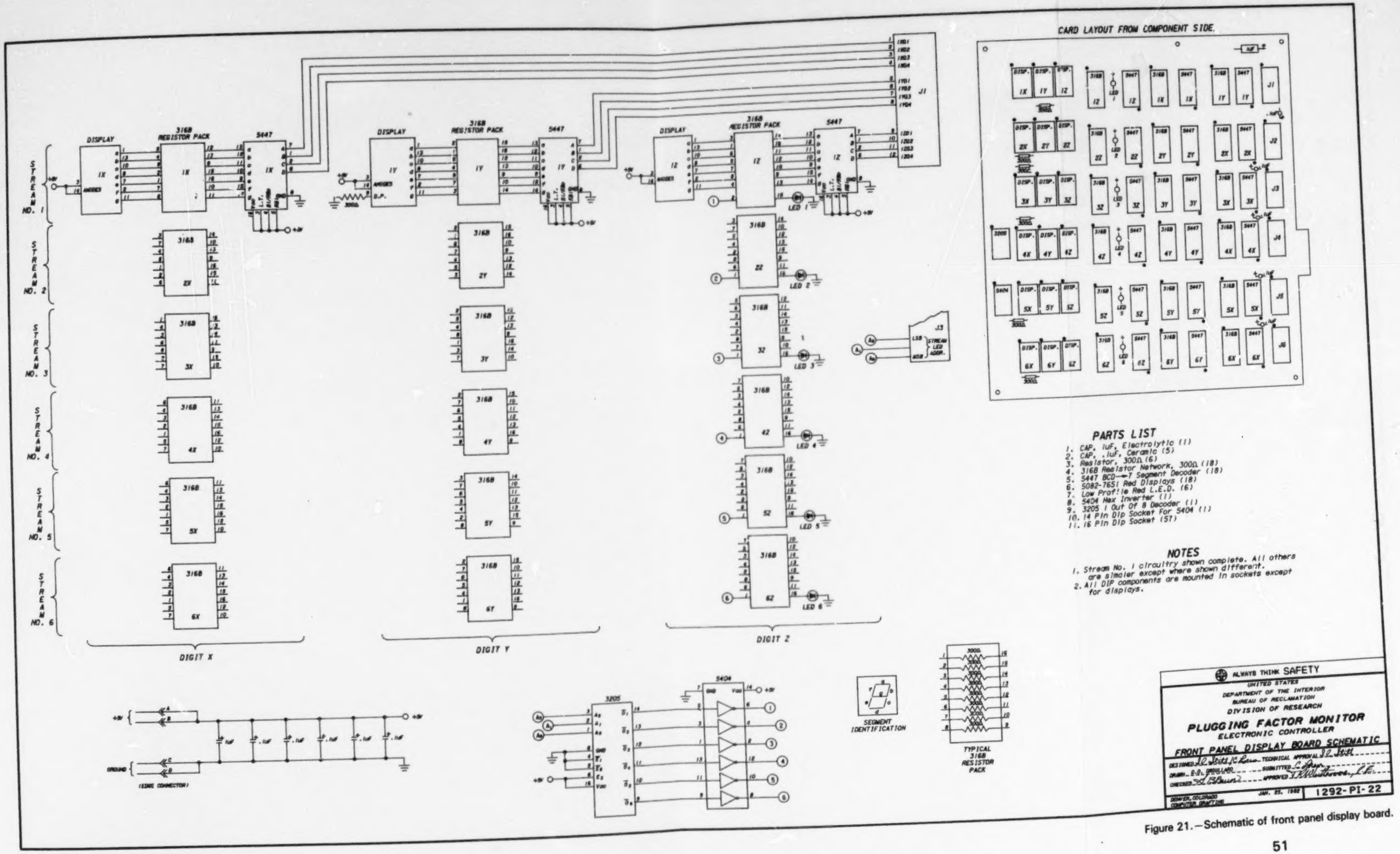
PLUGGING FACTOR MONITOR
ELECTRONIC CONTROLLER

FRONT PANEL ALARM BOARD SCHEMATIC

DESIGNED [illegible] TECHNICAL APPROVAL [illegible]
DRAWN [illegible] SUBMITTED C. [illegible]
CHECKED [illegible] APPROVED [illegible], P.E.
DENVER, COLORADO
COMPUTER DRAFTING
JAN. 25, 1982
1292-PI-21

Figure 20.—Schematic of front panel alarm board.


CARD LAYOUT FROM COMPONENT SIDE.
DISPLAY
3168 RESISTOR PACK
5447
ANODES
D.P.
300Ω
+5V
1X
1Y
1Z
J1
J2
J3
J4
J5
J6
LED 1
LED 2
LED 3
LED 4
LED 5
LED 6
STREAM NO. 1
STREAM NO. 2
STREAM NO. 3
STREAM NO. 4
STREAM NO. 5
STREAM NO. 6
3168
DIGIT X
DIGIT Y
DIGIT Z
LSB
MSB
STREAM LED ADDR.
3205
5404
GND
VDD
.1uF
GROUND
(EDGE CONNECTOR)
SEGMENT IDENTIFICATION
TYPICAL 3168 RESISTOR PACK

PARTS LIST

1. CAP, 1uF, Electrolytic (1)
2. CAP, .1uF, Ceramic (5)
3. Resistor, 300Ω (6)
4. 3168 Resistor Network, 300Ω (18)
5. 5447 BCD→7 Segment Decoder (18)
6. 5082-7651 Red Displays (18)
7. Low Profile Red L.E.D. (6)
8. 5404 Hex Inverter (1)
9. 3205 1 Out Of 8 Decoder (1)
10. 14 Pin Dip Socket For 5404 (1)
11. 16 Pin Dip Socket (57)

NOTES

1. Stream No. 1 circuitry shown complete. All others are similar except where shown different.
2. All DIP components are mounted in sockets except for displays.

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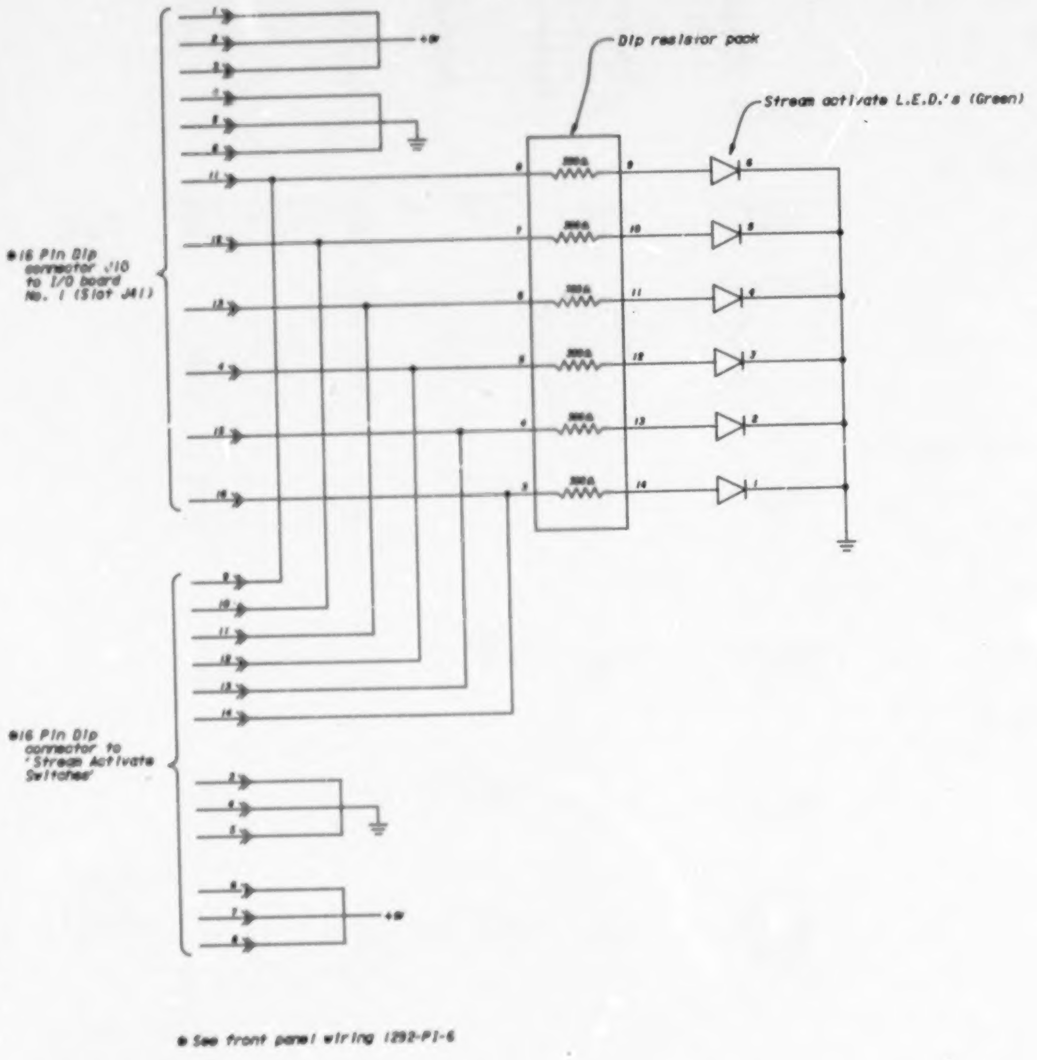
DIVISION OF RESEARCH

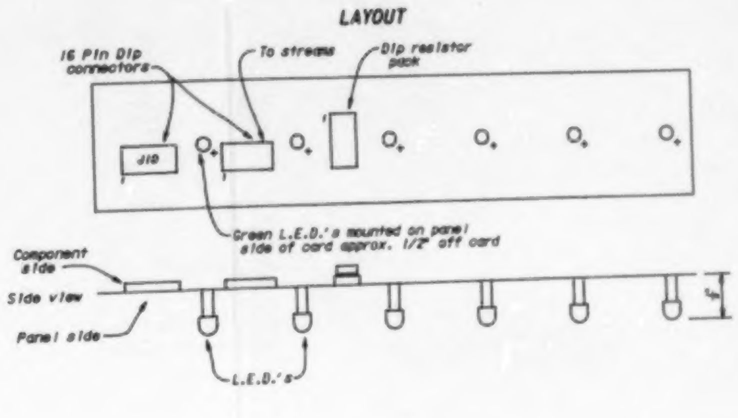
PLUGGING FACTOR MONITOR
ELECTRONIC CONTROLLER
FRONT PANEL DISPLAY BOARD SCHEMATIC

DESIGNED
TECHNICAL APPROVAL
DRAWN
SUBMITTED
CHECKED
APPROVED

DENVER, COLORADO
COMPUTER DRAFTING
JAN. 25, 1982
1292-PI-22

Figure 21.—Schematic of front panel display board.


+5V
Dip resistor pack
Stream activate L.E.D.'s (Green)
*16 Pin Dip connector J10 to I/O board No. 1 (Slot J41)
300Ω
*16 Pin Dip connector to 'Stream Activate Switches'
+5V
* See front panel wiring 1292-PI-6


LAYOUT
16 Pin Dip connectors
To streams
Dip resistor pack
J10
Green L.E.D.'s mounted on panel side of card approx. 1/2" off card
Component side
Side view
Panel side
L.E.D.'s

PARTS LIST

1. Dip Resistor Pack, 300Ω, Allen-Bradley 316B301, (1)
2. L.E.D.'s, Green, HP-508-4955 (6)
3. Socket, 16-Pin Dip, (3)

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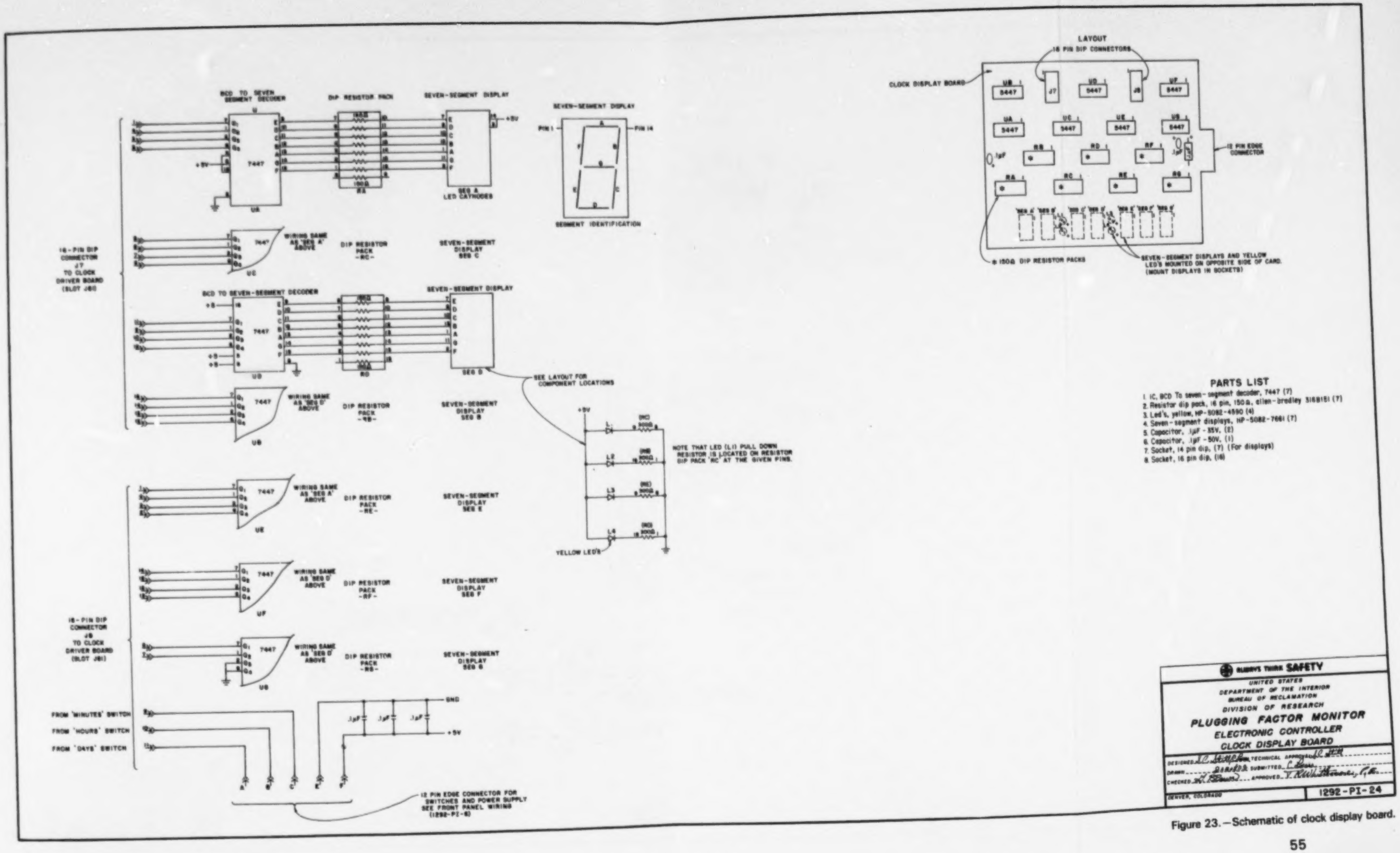
PLUGGING FACTOR MONITOR
ELECTRONIC CONTROLLER
STREAM ACTIVATE BOARD SCHEMATIC

1292-PI-23

Figure 22.—Schematic of stream activate board.


BCD TO SEVEN SEGMENT DECODER
DIP RESISTOR PACK
SEVEN-SEGMENT DISPLAY
7447
UA
RA
150Ω
+5V
SEG A LED CATHODES
SEVEN-SEGMENT DISPLAY
PIN 1
PIN 14
A
B
C
D
E
F
G
SEGMENT IDENTIFICATION
16-PIN DIP CONNECTOR J7 TO CLOCK DRIVER BOARD (SLOT J60)
WIRING SAME AS 'SEG A' ABOVE
DIP RESISTOR PACK -RC-
SEVEN-SEGMENT DISPLAY SEG C
UC
BCD TO SEVEN-SEGMENT DECODER
SEVEN-SEGMENT DISPLAY
UD
RD
SEG D
SEE LAYOUT FOR COMPONENT LOCATIONS
WIRING SAME AS 'SEG D' ABOVE
DIP RESISTOR PACK -RB-
SEVEN-SEGMENT DISPLAY SEG B
UB
+5V
L1
L2
L3
L4
(RC)
300Ω
YELLOW LED'S
NOTE THAT LED (L1) PULL DOWN RESISTOR IS LOCATED ON RESISTOR DIP PACK 'RC' AT THE GIVEN PINS.
WIRING SAME AS 'SEG A' ABOVE
DIP RESISTOR PACK -RE-
SEVEN-SEGMENT DISPLAY SEG E
UE
WIRING SAME AS 'SEG D' ABOVE
DIP RESISTOR PACK -RF-
SEVEN-SEGMENT DISPLAY SEG F
UF
16-PIN DIP CONNECTOR J8 TO CLOCK DRIVER BOARD (SLOT J61)
WIRING SAME AS 'SEG D' ABOVE
DIP RESISTOR PACK -RG-
SEVEN-SEGMENT DISPLAY SEG G
UG
FROM 'MINUTES' SWITCH
FROM 'HOURS' SWITCH
FROM 'DAYS' SWITCH
GND
.1µF
+5V
12 PIN EDGE CONNECTOR FOR SWITCHES AND POWER SUPPLY SEE FRONT PANEL WIRING (1292-PI-8)
LAYOUT
16 PIN DIP CONNECTORS
CLOCK DISPLAY BOARD
5447
J7
J8
UA
UB
UC
UD
UE
UF
UG
RA
RB
RC
RD
RE
RF
RG
.1µF
12 PIN EDGE CONNECTOR
'SEG A'
'SEG B'
'SEG C'
'SEG D'
'SEG E'
'SEG F'
'SEG G'
* 150Ω DIP RESISTOR PACKS
SEVEN-SEGMENT DISPLAYS AND YELLOW LED'S MOUNTED ON OPPOSITE SIDE OF CARD. (MOUNT DISPLAYS IN SOCKETS)

PARTS LIST

1. IC, BCD To seven-segment decoder, 7447 (7)
2. Resistor dip pack, 16 pin, 150Ω, allen-bradley 316B151 (7)
3. Led's, yellow, HP-5082-4590 (4)
4. Seven-segment displays, HP-5082-7661 (7)
5. Capacitor, .1µF - 35V, (2)
6. Capacitor, .1µF - 50V, (1)
7. Socket, 14 pin dip, (7) (For displays)
8. Socket, 16 pin dip, (16)

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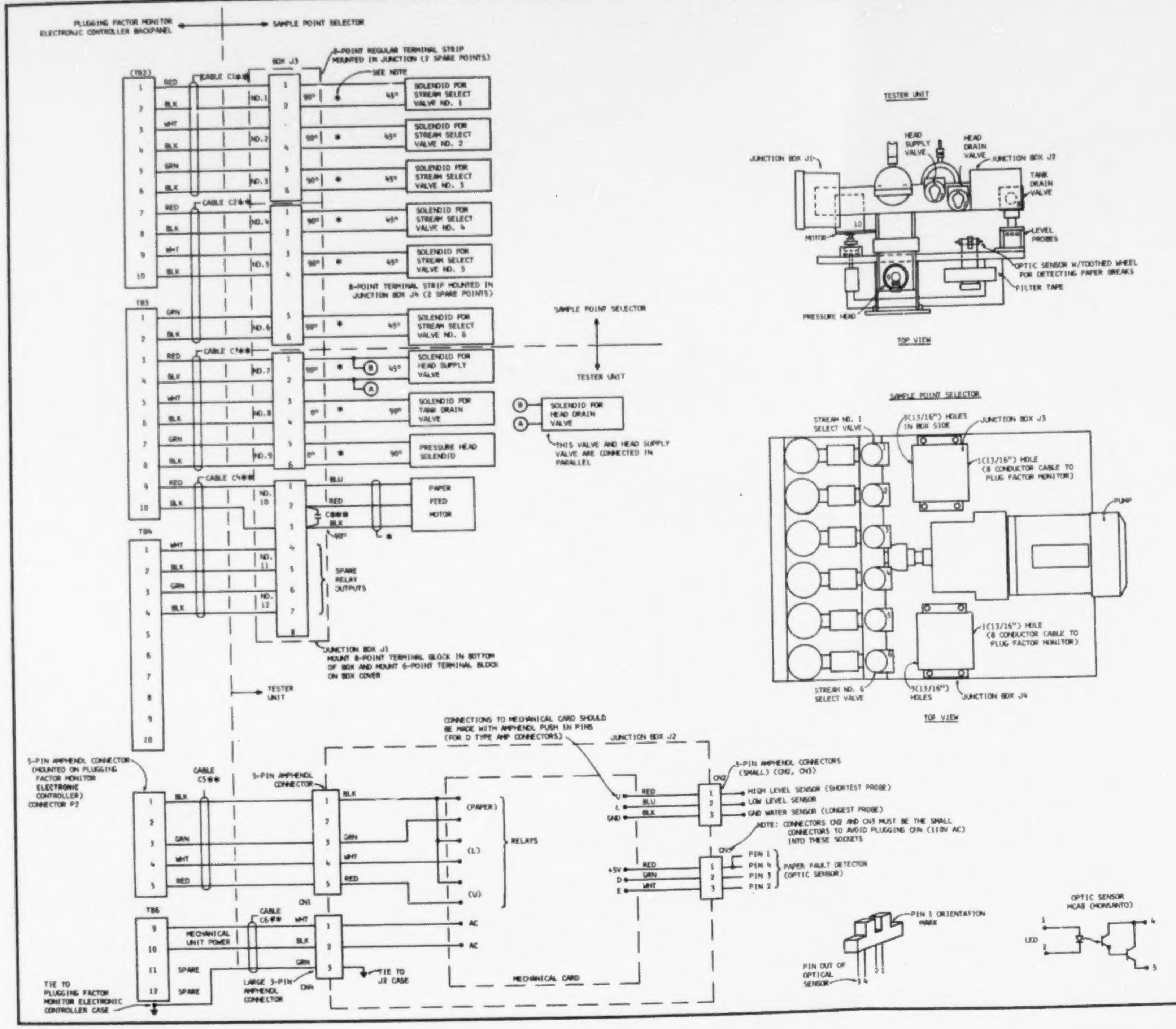
PLUGGING FACTOR MONITOR
ELECTRONIC CONTROLLER
CLOCK DISPLAY BOARD

DESIGNED J.C. Sample TECHNICAL APPROVAL J.C. [illegible]
DRAWN [illegible] SUBMITTED C. [illegible]
CHECKED [illegible] APPROVED V. R. Whittemore, C.E.

DENVER, COLORADO 1292-PI-24

Figure 23.—Schematic of clock display board.


PLUGGING FACTOR MONITOR ELECTRONIC CONTROLLER BACKPANEL
SAMPLE POINT SELECTOR
(TB2)
TB3
TB4
TB6
RED
BLK
WHT
GRN
BLU
CABLE C1**
CABLE C2**
CABLE C7**
CABLE C4**
CABLE C5**
CABLE C6**
BOX J3
8-POINT REGULAR TERMINAL STRIP MOUNTED IN JUNCTION (2 SPARE POINTS)
SEE NOTE
NO.1
NO.2
NO.3
NO.4
NO.5
NO.6
NO.7
NO.8
NO.9
NO. 10
NO. 11
NO. 12
90°
45°
0°
SOLENOID FOR STREAM SELECT VALVE NO. 1
SOLENOID FOR STREAM SELECT VALVE NO. 2
SOLENOID FOR STREAM SELECT VALVE NO. 3
SOLENOID FOR STREAM SELECT VALVE NO. 4
SOLENOID FOR STREAM SELECT VALVE NO. 5
8-POINT TERMINAL STRIP MOUNTED IN JUNCTION BOX J4 (2 SPARE POINTS)
SOLENOID FOR STREAM SELECT VALVE NO. 6
SOLENOID FOR HEAD SUPPLY VALVE
SOLENOID FOR TANK DRAIN VALVE
PRESSURE HEAD SOLENOID
PAPER FEED MOTOR
C***
SPARE RELAY OUTPUTS
JUNCTION BOX J1 MOUNT 8-POINT TERMINAL BLOCK IN BOTTOM OF BOX AND MOUNT 6-POINT TERMINAL BLOCK ON BOX COVER
SAMPLE POINT SELECTOR
TESTER UNIT
SOLENOID FOR HEAD DRAIN VALVE
THIS VALVE AND HEAD SUPPLY VALVE ARE CONNECTED IN PARALLEL
TESTER UNIT
5-PIN AMPHENOL CONNECTOR (MOUNTED ON PLUGGING FACTOR MONITOR ELECTRONIC CONTROLLER) CONNECTOR P2
5-PIN AMPHENOL CONNECTOR
CN1
MECHANICAL UNIT POWER
SPARE
LARGE 3-PIN AMPHENOL CONNECTOR
CN4
TIE TO J2 CASE
TIE TO PLUGGING FACTOR MONITOR ELECTRONIC CONTROLLER CASE
CONNECTIONS TO MECHANICAL CARD SHOULD BE MADE WITH AMPHENOL PUSH IN PINS (FOR D TYPE AMP CONNECTORS)
JUNCTION BOX J2
(PAPER)
(L)
(U)
RELAYS
AC
MECHANICAL CARD
U
L
GND
+5V
D
E
CN2
CN3
3-PIN AMPHENOL CONNECTORS (SMALL) (CN2, CN3)
HIGH LEVEL SENSOR (SHORTEST PROBE)
LOW LEVEL SENSOR
GND WATER SENSOR (LONGEST PROBE)
NOTE: CONNECTORS CN2 AND CN3 MUST BE THE SMALL CONNECTORS TO AVOID PLUGGING CN4 (110V AC) INTO THESE SOCKETS
PIN 1
PIN 4
PIN 3
PIN 2
PAPER FAULT DETECTOR (OPTIC SENSOR)
PIN 1 ORIENTATION MARK
PIN OUT OF OPTICAL SENSOR
OPTIC SENSOR MCA8 (MONSANTO)
LED
TESTER UNIT
JUNCTION BOX J1
HEAD SUPPLY VALVE
HEAD DRAIN VALVE
JUNCTION BOX J2
TANK DRAIN VALVE
MOTOR
LEVEL PROBES
OPTIC SENSOR W/TOOTHED WHEEL FOR DETECTING PAPER BREAKS
FILTER TAPE
PRESSURE HEAD
TOP VIEW
SAMPLE POINT SELECTOR
STREAM NO. 1 SELECT VALVE
3(13/16") HOLES IN BOX SIDE
JUNCTION BOX J3
1(13/16") HOLE (8 CONDUCTOR CABLE TO PLUG FACTOR MONITOR)
PUMP
STREAM NO. 6 SELECT VALVE
3(13/16") HOLES
JUNCTION BOX J4
TOP VIEW

NOTES

* These cables shall be run inside the liquid tight flexible conduit provided by Code 1523. Liquid tight connectors shall be used at both ends of the conduit. The type of connector required at the conduit ends is given in degrees. (0° = straight connector) For the paper feed motor, no connector can be used at the motor end of the conduit. If required, RTV may be used to make a water-tight seal around the open end.

** Cables C1, C2, C3, C4 and C5 should be six conductor cable (No. 18). Cable C6 should be 3 conductor (No. 18). Cables C1, C2, C3 and C4 should be mounted in approximately 3' of liquid tight conduit on the cable ends opposite the plug factor monitor.

*** The Capacitor should be mounted on the terminal block and should be a .82µ F CAP (Polycabonate 200V). (Note - Bodine recommends a .85µ F CAP.)

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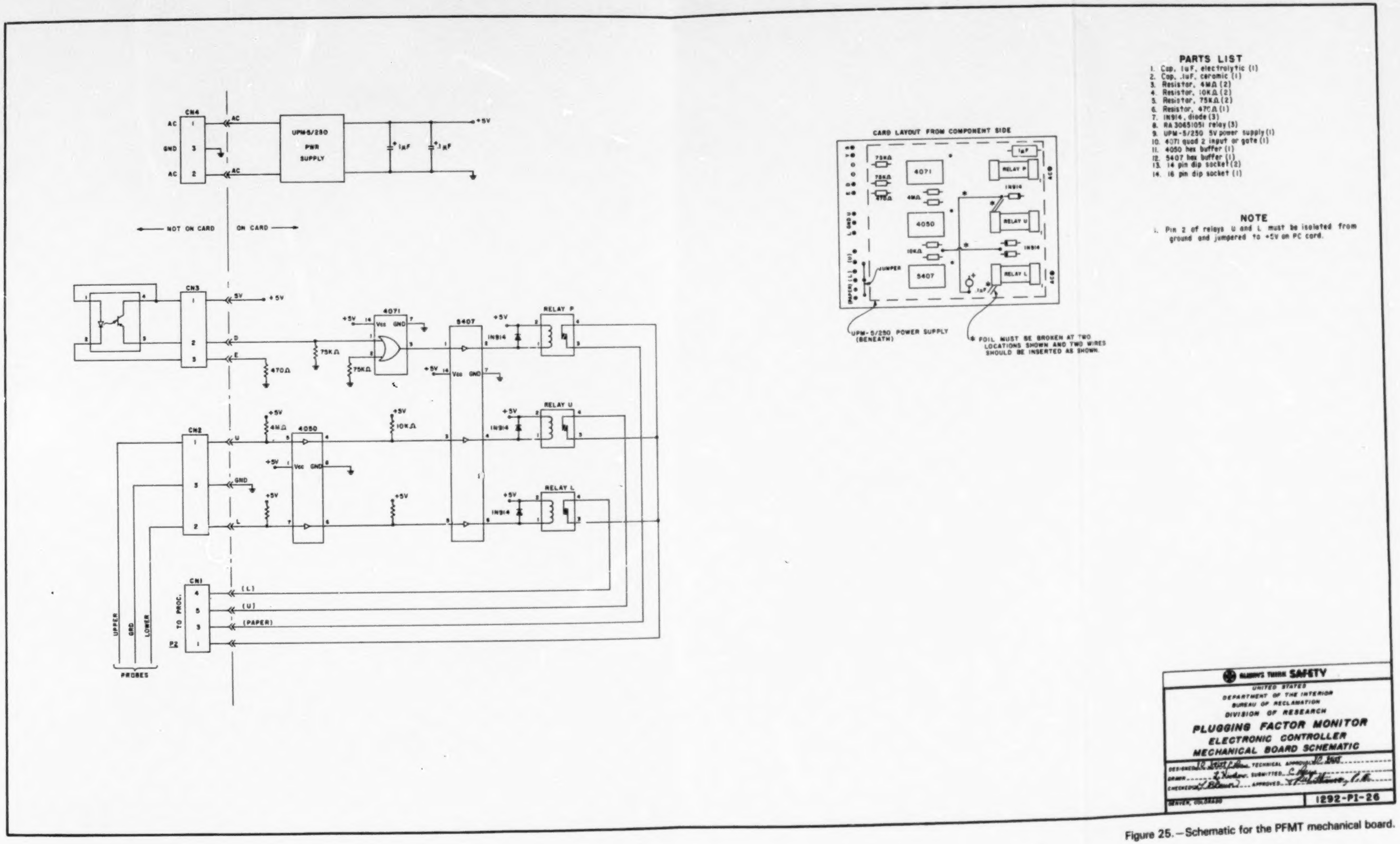
DIVISION OF RESEARCH

PLUGGING FACTOR MONITOR
TESTER AND
SAMPLE POINT SELECTOR BOOSTER PUMP
WIRING DIAGRAMS

DESIGNED .... TECHNICAL APPROVAL ....
DRAWN .... SUBMITTED C. Ben..........
CHECKED A. Blauw.......... APPROVED ....
DENVER, COLORADO
1292-PI-25

Figure 24.—Wiring diagram for the SPSBP and PFMT.


CN4
AC
GND
AC
UPM-5/250
PWR
SUPPLY
1µF
+5V
NOT ON CARD
ON CARD
CN3
5V
D
E
470Ω
75KΩ
4071
Vcc
GND
5407
RELAY P
IN914
RELAY U
RELAY L
CN2
U
GND
L
4MΩ
4050
10KΩ
CN1
(L)
(U)
(PAPER)
TO PROC.
P2
UPPER
GRD
LOWER
PROBES
CARD LAYOUT FROM COMPONENT SIDE
JUMPER
UPM-5/250 POWER SUPPLY (BENEATH)
* FOIL MUST BE BROKEN AT TWO LOCATIONS SHOWN AND TWO WIRES SHOULD BE INSERTED AS SHOWN.

PARTS LIST

1. Cap, 1uF, electrolytic (1)
2. Cap, .1uF, ceramic (1)
3. Resistor, 4MΩ (2)
4. Resistor, 10KΩ (2)
5. Resistor, 75KΩ (2)
6. Resistor, 470Ω (1)
7. IN914, diode (3)
8. RA 30651051 relay (3)
9. UPM-5/250 5V power supply (1)
10. 4071 quad 2 input or gate (1)
11. 4050 hex buffer (1)
12. 5407 hex buffer (1)
13. 14 pin dip socket (2)
14. 16 pin dip socket (1)

NOTE

1. Pin 2 of relays U and L must be isolated from ground and jumpered to +5V on PC card.

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MECHANICAL BOARD SCHEMATIC

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DRAWN [illegible] SUBMITTED [illegible]
CHECKED [illegible] APPROVED [illegible]
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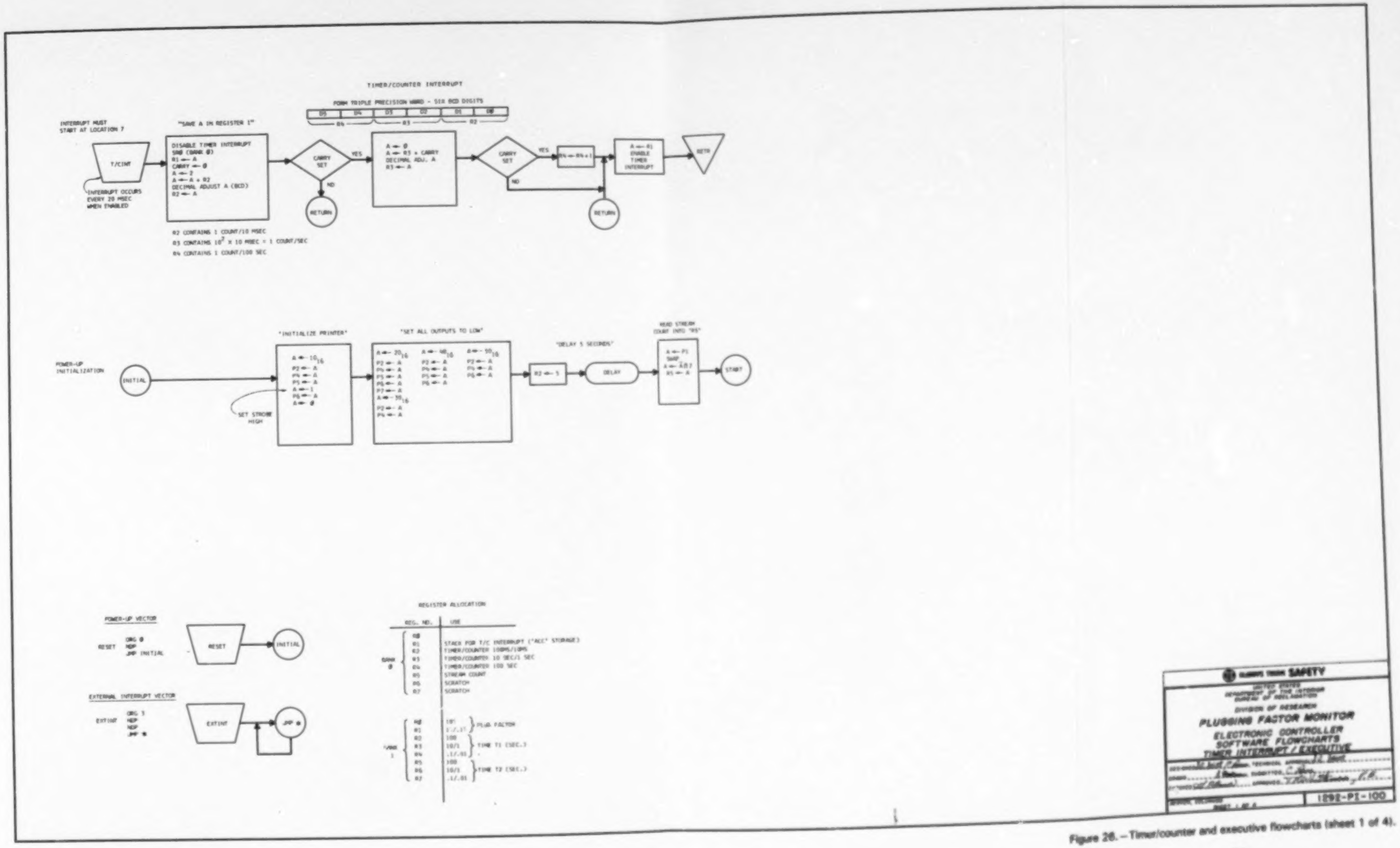
Figure 25.—Schematic for the PFMT mechanical board.


TIMER/COUNTER INTERRUPT
FORM TRIPLE PRECISION WORD - SIX BCD DIGITS
D5
D4
D3
D2
D1
D0
R4
R3
R2
INTERRUPT MUST START AT LOCATION 7
"SAVE A IN REGISTER 1"
T/CINT
INTERRUPT OCCURS EVERY 20 MSEC WHEN ENABLED
DISABLE TIMER INTERRUPT
SR0 (BANK 0)
R1 ← A
CARRY ← 0
A ← 2
A ← A + R2
DECIMAL ADJUST A (BCD)
R2 ← A
R2 CONTAINS 1 COUNT/10 MSEC
R3 CONTAINS 10² X 10 MSEC = 1 COUNT/SEC
R4 CONTAINS 1 COUNT/100 SEC
CARRY SET
YES
NO
RETURN
A ← 0
A ← R3 + CARRY
DECIMAL ADJ. A
R3 ← A
CARRY SET
YES
NO
R4 ← R4 + 1
RETURN
A ← R1
ENABLE TIMER INTERRUPT
RETR
POWER-UP INITIALIZATION
INITIAL
"INITIALIZE PRINTER"
A ← 10₁₆
P2 ← A
P4 ← A
P5 ← A
A ← 1
P6 ← A
A ← 0
SET STROBE HIGH
"SET ALL OUTPUTS TO LOW"
A ← 20₁₆
P2 ← A
P4 ← A
P5 ← A
P6 ← A
P7 ← A
A ← 30₁₆
P2 ← A
P4 ← A
A ← 40₁₆
P2 ← A
P4 ← A
P5 ← A
P6 ← A
A ← 50₁₆
P2 ← A
P4 ← A
P6 ← A
"DELAY 5 SECONDS"
R2 ← 5
DELAY
READ STREAM COUNT INTO "R5"
A ← P1
SWAP
A ← A∩7
R5 ← A
START
POWER-UP VECTOR
RESET
ORG 0
NOP
JMP INITIAL
RESET
INITIAL
EXTERNAL INTERRUPT VECTOR
EXTINT
ORG 3
NOP
NOP
JMP *
EXTINT
JMP *

REGISTER ALLOCATION

	REG. NO.	USE	
BANK 0	R0		
	R1	STACK FOR T/C INTERRUPT ("ACC" STORAGE)	
	R2	TIMER/COUNTER 100MS/10MS	
	R3	TIMER/COUNTER 10 SEC/1 SEC	
	R4	TIMER/COUNTER 100 SEC	
	R5	STREAM COUNT	
	R6	SCRATCH	
	R7	SCRATCH	
BANK 1	R0	10'	PLUG FACTOR
	R1	1'/.1'	
	R2	100	TIME T1 (SEC.)
	R3	10/1	
	R4	.1/.01	
	R5	100	TIME T2 (SEC.)
	R6	10/1	
	R7	.1/.01	

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Figure 26. – Timer/counter and executive flowcharts (sheet 1 of 4).

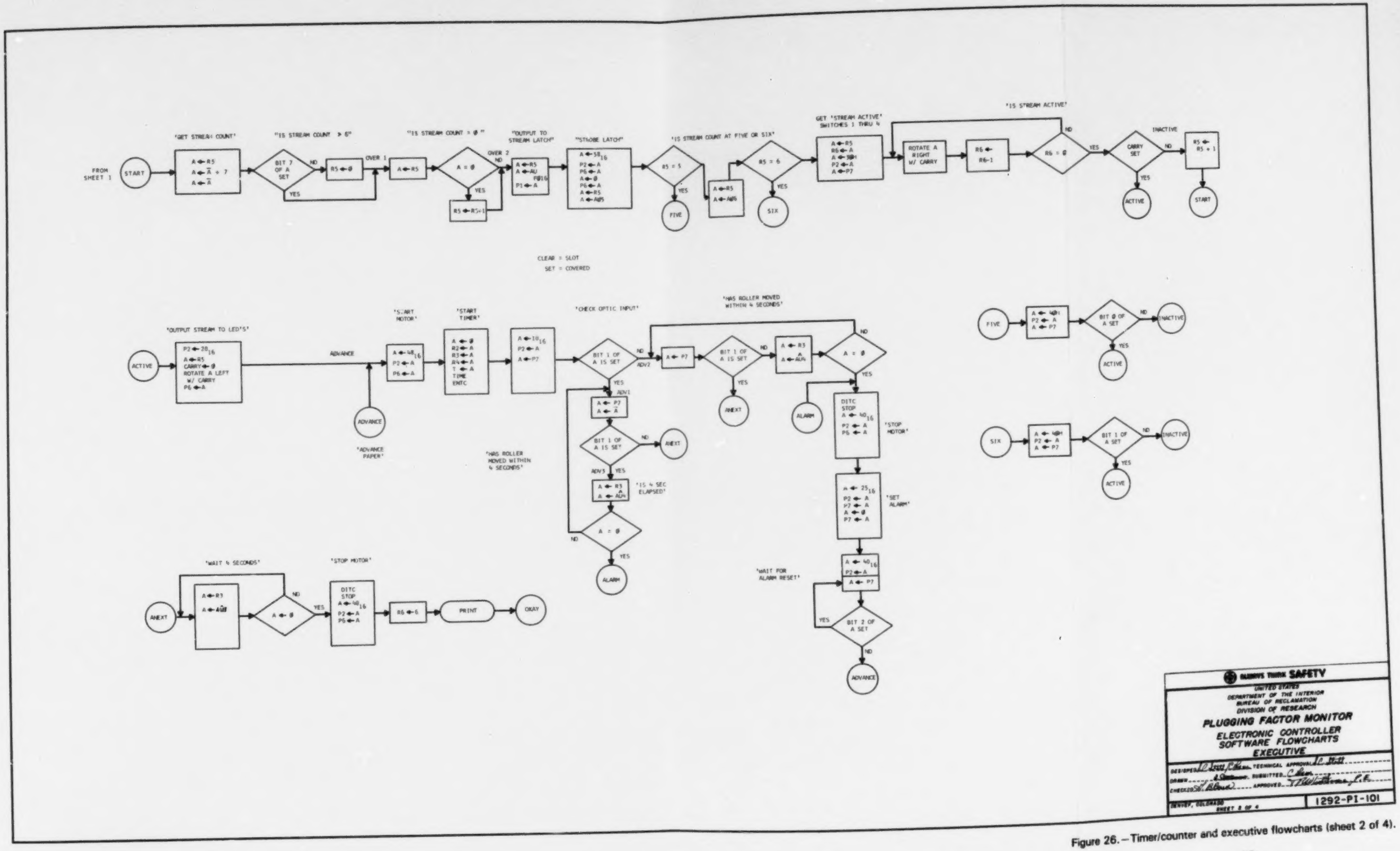
FROM SHEET 1
START
'GET STREAM COUNT'
A ← R5
A ← Ā + 7
A ← Ā
"IS STREAM COUNT > 6"
BIT 7 OF A SET
NO
YES
R5 ← 0
OVER 1
A ← R5
"IS STREAM COUNT = 0"
A = 0
YES
R5 ← R5+1
OVER 2
NO
"OUTPUT TO STREAM LATCH"
A ← R5
A ← AU F016
P1 ← A
"STROBE LATCH"
A ← 58₁₆
P2 ← A
P6 ← A
A ← 0
P6 ← A
A ← R5
A ← A05
'IS STREAM COUNT AT FIVE OR SIX'
R5 = 5
YES
FIVE
A ← R5
A ← A06
R5 = 6
YES
SIX
GET 'STREAM ACTIVE' SWITCHES 1 THRU 4
A ← R5
R6 ← A
A ← 50H
P2 ← A
A ← P7
ROTATE A RIGHT W/ CARRY
R6 ← R6-1
'IS STREAM ACTIVE'
R6 = 0
NO
YES
CARRY SET
YES
ACTIVE
INACTIVE
NO
R5 ← R5 + 1
START
CLEAR = SLOT
SET = COVERED
ACTIVE
'OUTPUT STREAM TO LED'S'
P2 ← 20₁₆
A ← R5
CARRY ← 0
ROTATE A LEFT W/ CARRY
P6 ← A
ADVANCE
ADVANCE
'ADVANCE PAPER'
'START MOTOR'
A ← 48₁₆
P2 ← A
P6 ← A
'START TIMER'
A ← 0
R2 ← A
R3 ← A
R4 ← A
T ← A
TIME
ENTC
A ← 10₁₆
P2 ← A
A ← P7
'CHECK OPTIC INPUT'
BIT 1 OF A IS SET
NO
ADV2
YES
ADV1
A ← P7
A ← Ā
BIT 1 OF A IS SET
NO
ANEXT
ADV3
YES
A ← R3
A ← AU4
'IS 4 SEC ELAPSED'
A = 0
NO
YES
ALARM
'HAS ROLLER MOVED WITHIN 4 SECONDS'
'HAS ROLLER MOVED WITHIN 4 SECONDS'
A ← P7
BIT 1 OF A IS SET
NO
YES
ANEXT
A ← R3
A ← AU4
A = 0
NO
YES
ALARM
DITC
STOP
A ← 40₁₆
P2 ← A
P6 ← A
'STOP MOTOR'
A ← 25₁₆
P2 ← A
P7 ← A
A ← 0
P7 ← A
'SET ALARM'
A ← 40₁₆
P2 ← A
A ← P7
'WAIT FOR ALARM RESET'
BIT 2 OF A SET
YES
NO
ADVANCE
FIVE
A ← 40H
P2 ← A
A ← P7
BIT 0 OF A SET
NO
INACTIVE
YES
ACTIVE
SIX
A ← 40H
P2 ← A
A ← P7
BIT 1 OF A SET
NO
INACTIVE
YES
ACTIVE
'WAIT 4 SECONDS'
ANEXT
A ← R3
A ← AUT
A ← 0
NO
YES
'STOP MOTOR'
DITC
STOP
A ← 40₁₆
P2 ← A
P6 ← A
R6 ← 6
PRINT
OKAY

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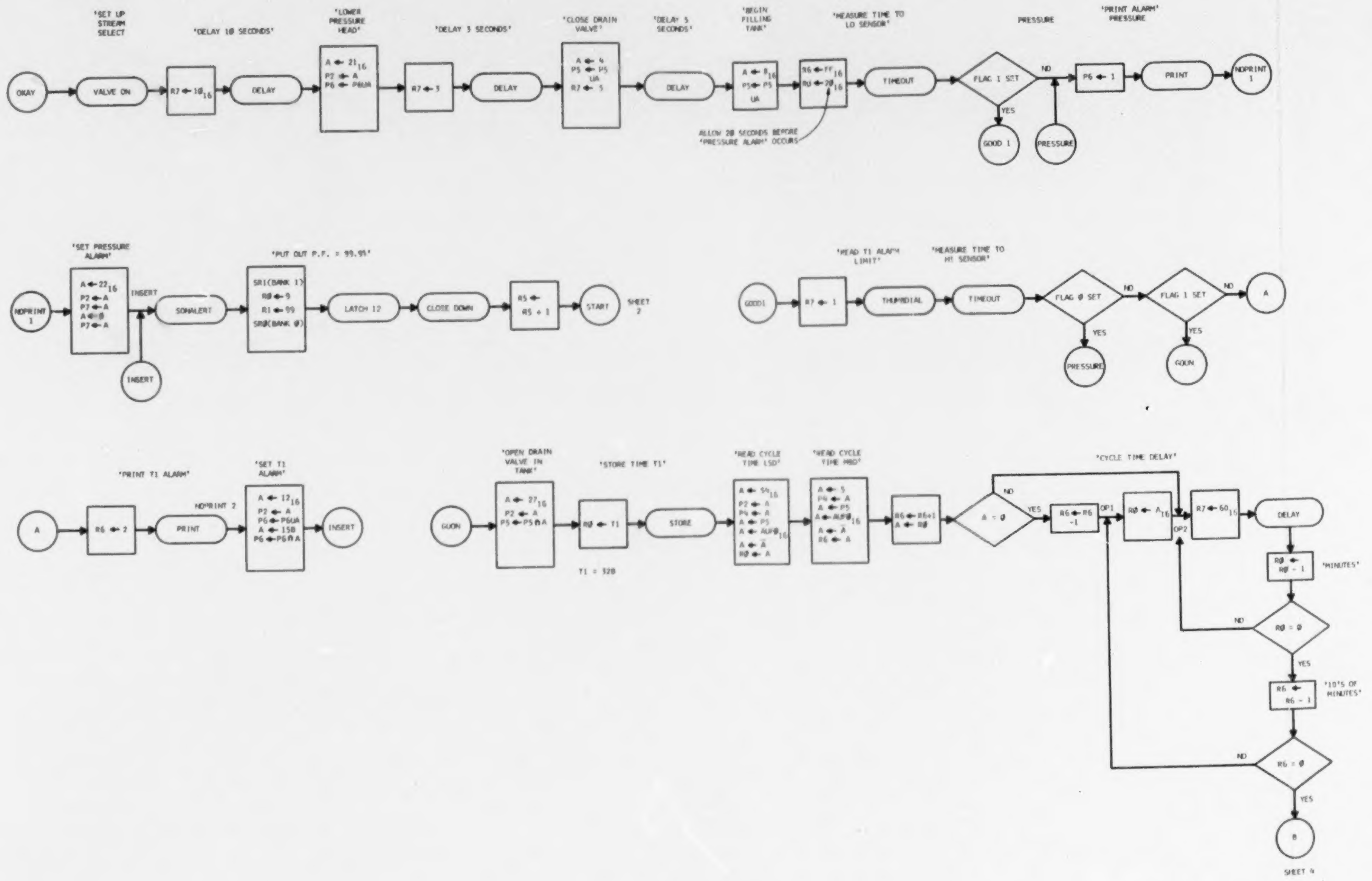
Figure 26.—Timer/counter and executive flowcharts (sheet 2 of 4).



'SET UP STREAM SELECT
'DELAY 10 SECONDS'
'LOWER PRESSURE HEAD'
'DELAY 3 SECONDS'
'CLOSE DRAIN VALVE'
'DELAY 5 SECONDS'
'BEGIN FILLING TANK'
'MEASURE TIME TO LO SENSOR'
PRESSURE
'PRINT ALARM' PRESSURE
OKAY
VALVE ON
$R7 \leftarrow 10_{16}$
DELAY
$A \leftarrow 21_{16}$
P2 ← A
P6 ← P6UA
R7 ← 3
DELAY
A ← 4
P5 ← P5 UA
R7 ← 5
DELAY
$A \leftarrow 8_{16}$
P5 ← P5 UA
$R6 \leftarrow FF_{16}$
$R0 \leftarrow 20_{16}$
TIMEOUT
FLAG 1 SET
NO
YES
P6 ← 1
PRINT
NOPRINT 1
GOOD 1
PRESSURE
ALLOW 20 SECONDS BEFORE 'PRESSURE ALARM' OCCURS
'SET PRESSURE ALARM'
'PUT OUT P.F. = 99.9%'
NOPRINT 1
$A \leftarrow 22_{16}$
P2 ← A
P7 ← A
A ← 0
P7 ← A
INSERT
INSERT
SONALERT
SR1(BANK 1)
R0 ← 9
R1 ← 99
SR0(BANK 0)
LATCH 12
CLOSE DOWN
R5 ← R5 + 1
START
SHEET 2
'READ T1 ALARM LIMIT'
'MEASURE TIME TO HI SENSOR'
GOOD1
R7 ← 1
THUMBDIAL
TIMEOUT
FLAG 0 SET
NO
YES
PRESSURE
FLAG 1 SET
NO
YES
GOON
A
'PRINT T1 ALARM'
'SET T1 ALARM'
A
R6 ← 2
PRINT
NOPRINT 2
$A \leftarrow 12_{16}$
P2 ← A
P6 ← P6UA
A ← 15B
P6 ← P6∩A
INSERT
'OPEN DRAIN VALVE IN TANK'
'STORE TIME T1'
'READ CYCLE TIME LSD'
'READ CYCLE TIME MSD'
'CYCLE TIME DELAY'
GOON
$A \leftarrow 27_{16}$
P2 ← A
P5 ← P5∩A
R0 ← T1
T1 = 32B
STORE
$A \leftarrow 54_{16}$
P2 ← A
P4 ← A
A ← P5
$A \leftarrow AUF0_{16}$
$A \leftarrow \bar{A}$
R0 ← A
A ← 5
P4 ← A
A ← P5
$A \leftarrow AUF0_{16}$
$A \leftarrow \bar{A}$
R6 ← A
R6 ← R6+1
A ← R0
A = 0
NO
YES
R6 ← R6 -1
OP1
$R0 \leftarrow A_{16}$
OP2
$R7 \leftarrow 60_{16}$
DELAY
R0 ← R0 - 1
'MINUTES'
R0 = 0
NO
YES
R6 ← R6 - 1
'10'S OF MINUTES'
R6 = 0
NO
YES
B
SHEET 4

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Figure 26.—Timer/counter and executive flowcharts (sheet 3 of 4).

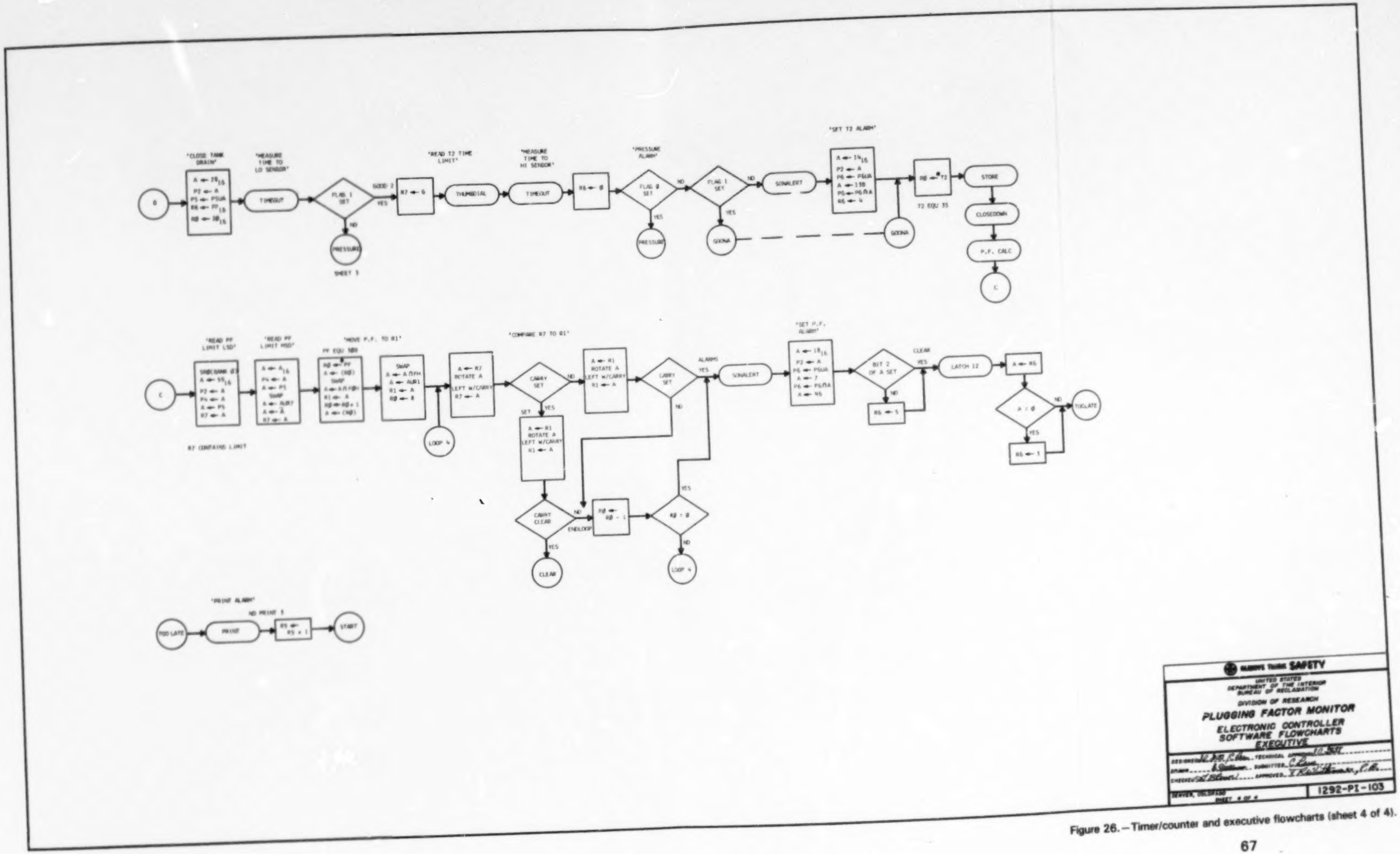
'CLOSE TANK DRAIN'
'MEASURE TIME TO LO SENSOR'
'READ T2 TIME LIMIT'
'MEASURE TIME TO HI SENSOR'
'PRESSURE ALARM'
'SET T2 ALARM'
B
A ← 28₁₆
P2 ← A
P5 ← P5UA
R6 ← FF₁₆
R0 ← 30₁₆
TIMEOUT
FLAG 1 SET
GOOD 2
YES
NO
PRESSURE
SHEET 3
R7 ← 6
THUMBDIAL
TIMEOUT
R6 ← 0
FLAG 0 SET
NO
YES
PRESSURE
FLAG 1 SET
NO
YES
GOONA
SONALERT
A ← 14₁₆
P2 ← A
P6 ← P6UA
A ← 13B
P6 ← P6 ∩ A
R6 ← 4
GOONA
R0 ← *T2
T2 EQU 35
STORE
CLOSEDOWN
P.F. CALC
C
'READ PF LIMIT LSD'
'READ PF LIMIT MSD'
'MOVE P.F. TO R1'
'COMPARE R7 TO R1'
'SET P.F. ALARM'
C
SB0(BANK 0)
A ← 59₁₆
P2 ← A
P4 ← A
A ← P5
R7 ← A
R7 CONTAINS LIMIT
A ← A₁₆
P4 ← A
A ← P5
SWAP
A ← A∪R7
A ← Ā
R7 ← A
PF EQU 3B0
R0 ← *PF
A ← (R0)
SWAP
A ← A∩F0H
R1 ← A
R0 ← R0 + 1
A ← (R0)
SWAP
A ← A∩FH
A ← A∪R1
R1 ← A
R0 ← 8
LOOP 4
A ← R7
ROTATE A
LEFT W/CARRY
R7 ← A
CARRY SET
NO
YES
SET
A ← R1
ROTATE A
LEFT W/CARRY
R1 ← A
A ← R1
ROTATE A
LEFT W/CARRY
R1 ← A
CARRY SET
ALARMS
YES
NO
CARRY CLEAR
NO
ENDLOOP
YES
CLEAR
R0 ← R0 - 1
R0 = 0
YES
NO
LOOP 4
SONALERT
A ← 18₁₆
P2 ← A
P6 ← P6UA
A ← 7
P6 ← P6∩A
A ← R6
BIT 2 OF A SET
CLEAR
YES
NO
R6 ← 5
LATCH 12
A ← R6
A = 0
NO
YES
R6 ← 3
TOOLATE
'PRINT ALARM'
NO PRINT 3
TOO LATE
PRINT
R5 ← R5 + 1
START
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Figure 26.—Timer/counter and executive flowcharts (sheet 4 of 4).

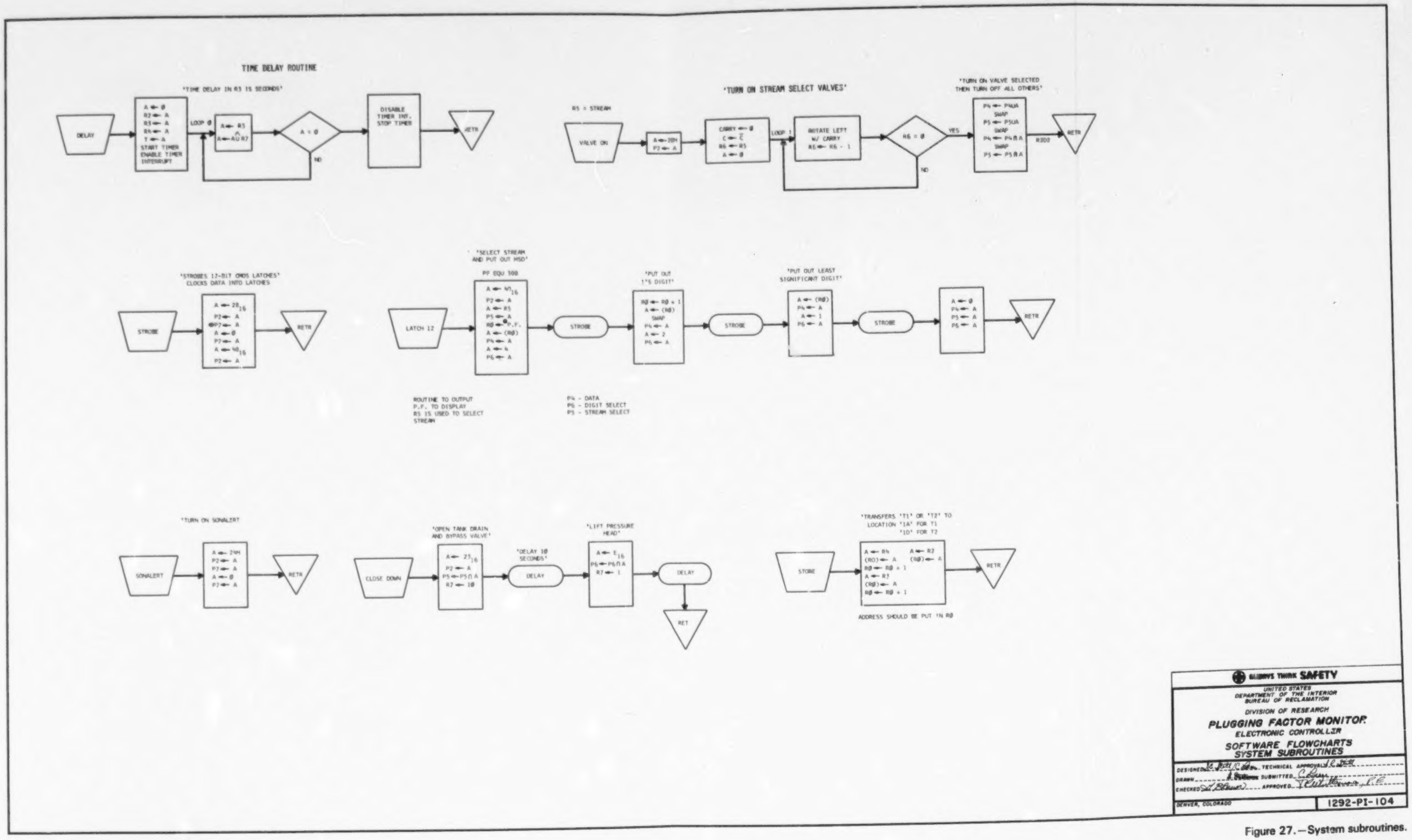
TIME DELAY ROUTINE
'TIME DELAY IN R3 IS SECONDS'
DELAY
A ← 0
R2 ← A
R3 ← A
R4 ← A
T ← A
START TIMER
ENABLE TIMER
INTERRUPT
LOOP 0
A ← R3
A ← A ∪̂ R7
A = 0
NO
DISABLE
TIMER INT.
STOP TIMER
RETR
'TURN ON STREAM SELECT VALVES'
R5 = STREAM
VALVE ON
A ← 20H
P2 ← A
CARRY ← 0
C ← C̄
R6 ← R5
A ← 0
LOOP 1
ROTATE LEFT
W/ CARRY
R6 ← R6 - 1
R6 = 0
YES
NO
'TURN ON VALVE SELECTED
THEN TURN OFF ALL OTHERS'
P4 ← P4UA
SWAP
P5 ← P5UA
SWAP
P4 ← P4 ∩ A
SWAP
P5 ← P5 ∩ A
R3D2
RETR
'STROBES 12-BIT CMOS LATCHES'
CLOCKS DATA INTO LATCHES
STROBE
A ← 28₁₆
P2 ← A
P7 ← A
A ← 0
P7 ← A
A ← 40₁₆
P2 ← A
RETR
'SELECT STREAM
AND PUT OUT MSD'
PF EQU 300
LATCH 12
A ← 40₁₆
P2 ← A
A ← R5
P5 ← A
R0 ← P.F.
A ← (R0)
P4 ← A
A ← 4
P6 ← A
STROBE
'PUT OUT
1'S DIGIT'
R0 ← R0 + 1
A ← (R0)
SWAP
P4 ← A
A ← 2
P6 ← A
STROBE
'PUT OUT LEAST
SIGNIFICANT DIGIT'
A ← (R0)
P4 ← A
A ← 1
P6 ← A
STROBE
A ← 0
P4 ← A
P5 ← A
P6 ← A
RETR
ROUTINE TO OUTPUT
P.F. TO DISPLAY
R5 IS USED TO SELECT
STREAM
P4 - DATA
P6 - DIGIT SELECT
P5 - STREAM SELECT
'TURN ON SONALERT
SONALERT
A ← 2AH
P2 ← A
P7 ← A
A ← 0
P7 ← A
RETR
'OPEN TANK DRAIN
AND BYPASS VALVE'
CLOSE DOWN
A ← 23₁₆
P2 ← A
P5 ← P5 ∩ A
R7 ← 10
'DELAY 10
SECONDS'
DELAY
'LIFT PRESSURE
HEAD'
A ← E₁₆
P6 ← P6 ∩ A
R7 ← 1
DELAY
RET
'TRANSFERS 'T1' OR 'T2' TO
LOCATION '1A' FOR T1
'1D' FOR T2
STORE
A ← R4
(R0) ← A
R0 ← R0 + 1
A ← R3
(R0) ← A
R0 ← R0 + 1
A ← R2
(R0) ← A
RETR
ADDRESS SHOULD BE PUT IN R0
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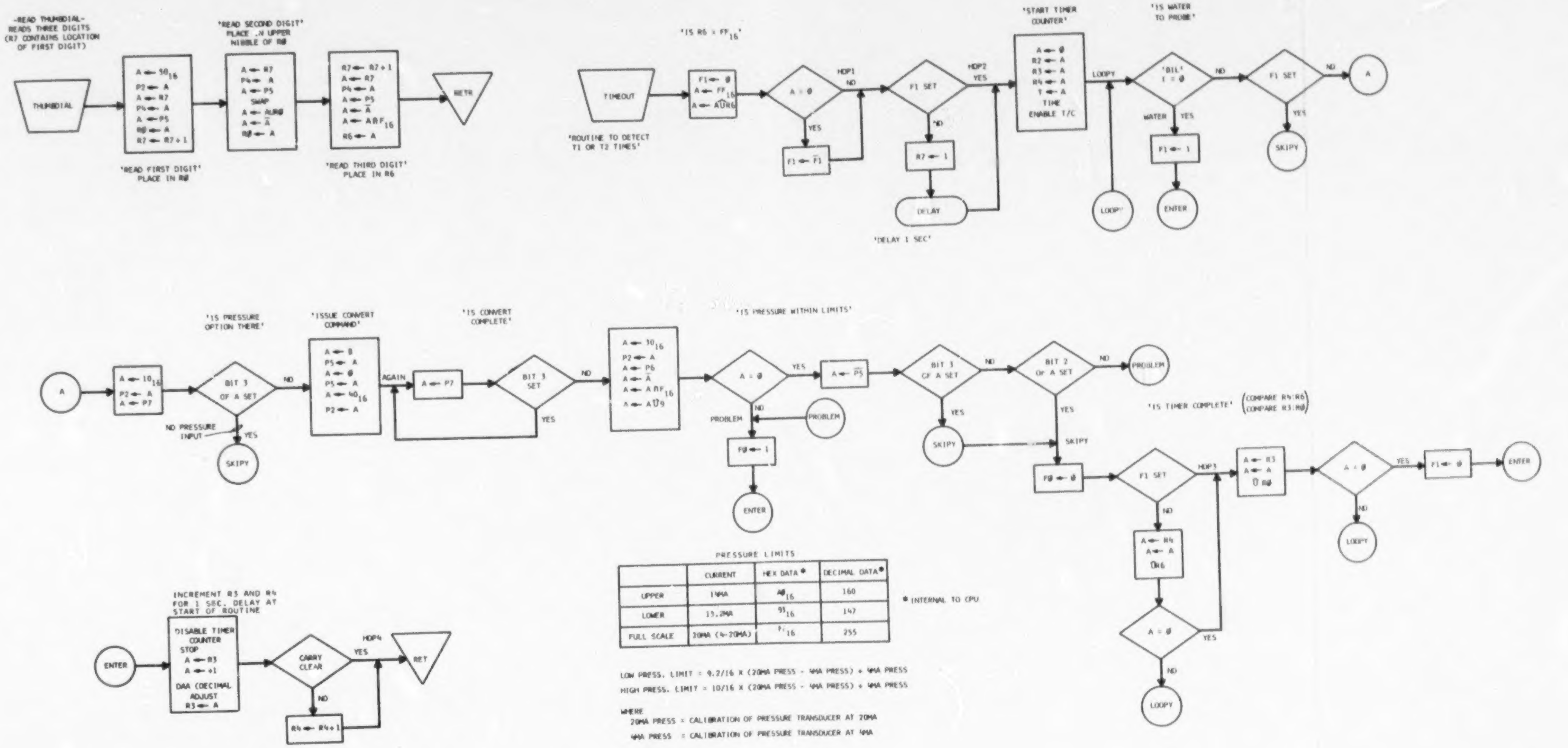
Figure 27.—System subroutines.


-READ THUMBDIAL-
READS THREE DIGITS
(R7 CONTAINS LOCATION
OF FIRST DIGIT)
THUMBDIAL
$A \leftarrow 30_{16}$
$P2 \leftarrow A$
$A \leftarrow R7$
$P4 \leftarrow A$
$A \leftarrow P5$
$R0 \leftarrow A$
$R7 \leftarrow R7 + 1$
'READ FIRST DIGIT'
PLACE IN R0
'READ SECOND DIGIT'
PLACE .N UPPER
NIBBLE OF R0
$A \leftarrow R7$
$P4 \leftarrow A$
$A \leftarrow P5$
SWAP
$A \leftarrow A \cup R0$
$A \leftarrow \bar{A}$
$R0 \leftarrow A$
$R7 \leftarrow R7 + 1$
$A \leftarrow R7$
$P4 \leftarrow A$
$A \leftarrow P5$
$A \leftarrow \bar{A}$
$A \leftarrow A \cap F_{16}$
$R6 \leftarrow A$
'READ THIRD DIGIT'
PLACE IN R6
RETR
'IS R6 = FF$_{16}$'
TIMEOUT
'ROUTINE TO DETECT
T1 OR T2 TIMES'
$F1 \leftarrow 0$
$A \leftarrow FF_{16}$
$A \leftarrow \widehat{A \cup R6}$
A = 0
YES
$F1 \leftarrow \bar{F1}$
HOP1
NO
F1 SET
NO
$R7 \leftarrow 1$
DELAY
'DELAY 1 SEC'
HOP2
YES
'START TIMER
COUNTER'
$A \leftarrow 0$
$R2 \leftarrow A$
$R3 \leftarrow A$
$R4 \leftarrow A$
$T \leftarrow A$
TIME
ENABLE T/C
LOOPY
LOOPY
'IS WATER
TO PROBE'
'BIL'
1 = 0
WATER
YES
$F1 \leftarrow 1$
ENTER
NO
F1 SET
YES
SKIPY
NO
A
A
$A \leftarrow 10_{16}$
$P2 \leftarrow A$
$A \leftarrow P7$
'IS PRESSURE
OPTION THERE'
BIT 3
OF A SET
NO PRESSURE
INPUT
YES
SKIPY
NO
'ISSUE CONVERT
COMMAND'
$A \leftarrow B$
$P5 \leftarrow A$
$A \leftarrow 0$
$P5 \leftarrow A$
$A \leftarrow 40_{16}$
$P2 \leftarrow A$
AGAIN
$A \leftarrow P7$
'IS CONVERT
COMPLETE'
BIT 3
SET
YES
NO
$A \leftarrow 30_{16}$
$P2 \leftarrow A$
$A \leftarrow P6$
$A \leftarrow \bar{A}$
$A \leftarrow A \cap F_{16}$
$A \leftarrow A \cup 9$
'IS PRESSURE WITHIN LIMITS'
A = 0
YES
$A \leftarrow \overline{P5}$
NO
PROBLEM
PROBLEM
$F0 \leftarrow 1$
ENTER
BIT 3
OF A SET
YES
SKIPY
NO
BIT 2
OF A SET
NO
PROBLEM
YES
SKIPY
'IS TIMER COMPLETE' (COMPARE R4:R6
COMPARE R3:R0)
$F0 \leftarrow 0$
F1 SET
HOP3
NO
$A \leftarrow R4$
$A \leftarrow A$
$\cup R6$
A = 0
YES
NO
LOOPY
$A \leftarrow R3$
$A \leftarrow A$
$\cup R0$
A = 0
YES
NO
LOOPY
$F1 \leftarrow 0$
ENTER
INCREMENT R3 AND R4
FOR 1 SEC. DELAY AT
START OF ROUTINE
ENTER
DISABLE TIMER
COUNTER
STOP
$A \leftarrow R3$
$A \leftarrow +1$
DAA (DECIMAL
ADJUST
$R3 \leftarrow A$
CARRY
CLEAR
HOP4
YES
NO
$R4 \leftarrow R4 + 1$
RET

PRESSURE LIMITS

	CURRENT	HEX DATA *	DECIMAL DATA *
UPPER	14MA	$A0_{16}$	160
LOWER	13.2MA	93_{16}	147
FULL SCALE	20MA (4-20MA)	FF_{16}	255

* INTERNAL TO CPU

LOW PRESS. LIMIT = 9.2/16 X (20MA PRESS - 4MA PRESS) + 4MA PRESS
HIGH PRESS. LIMIT = 10/16 X (20MA PRESS - 4MA PRESS) + 4MA PRESS

WHERE
20MA PRESS = CALIBRATION OF PRESSURE TRANSDUCER AT 20MA
4MA PRESS = CALIBRATION OF PRESSURE TRANSDUCER AT 4MA

ASSUME
4MA PRESS = 0KP 20MA PRESS = 350KP

THEN
HIGH LIMIT = 218KP
LOW LIMIT = 201KP

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SUBROUTINES THUMBDIAL & TIMEOUT

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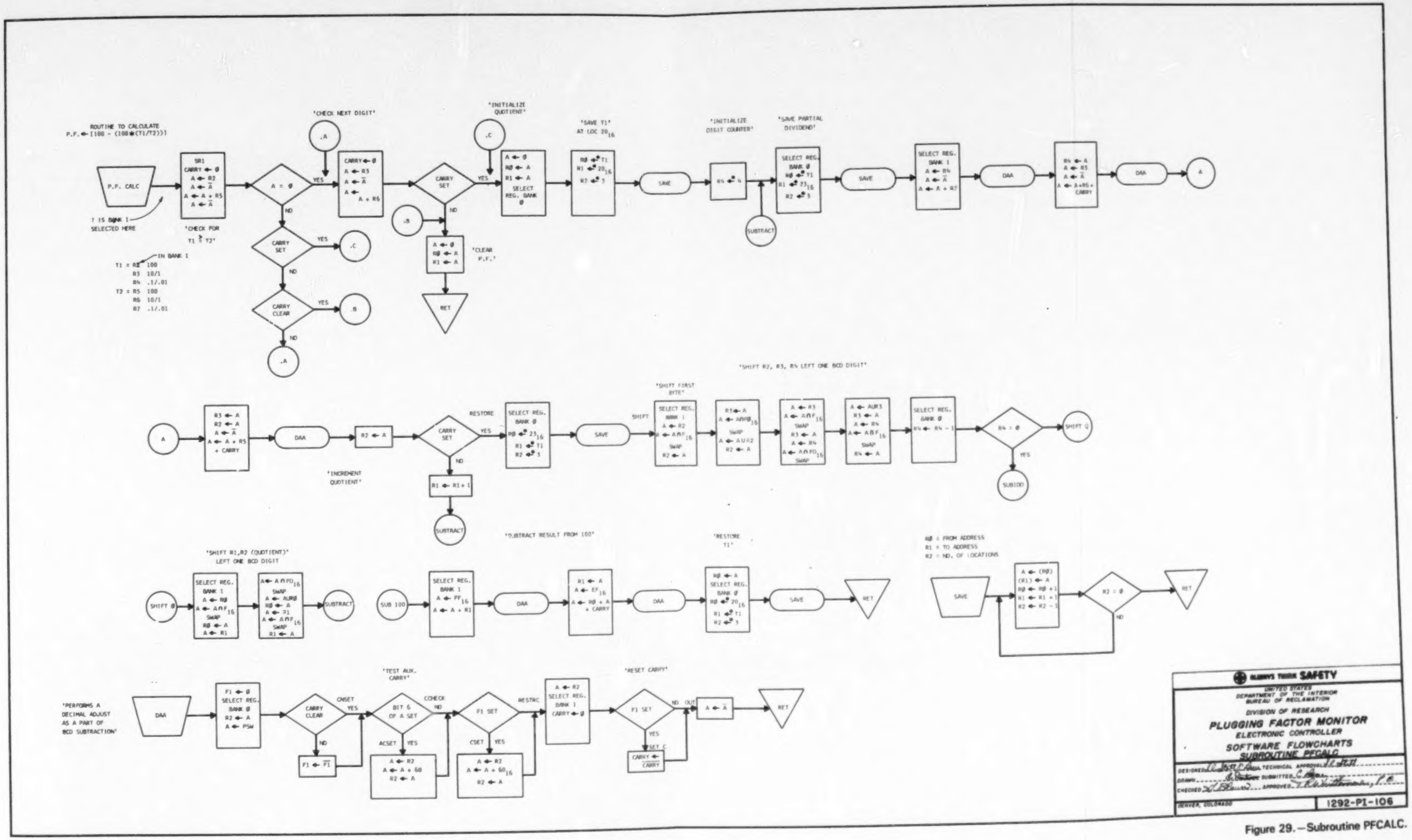
Figure 28.—Subroutines THUMBDIAL and TIMEOUT.


ROUTINE TO CALCULATE
P.F. ← [100 - (100 * (T1/T2))]
P.F. CALC
? IS BANK 1 SELECTED HERE
SR1
CARRY ← 0
A ← R2
A ← Ā
A ← A + R5
A ← Ā
'CHECK FOR T1 ≥ T2'
IN BANK 1
T1 = R2 100
R3 10/1
R4 .1/.01
T2 = R5 100
R6 10/1
R7 .1/.01
'CHECK NEXT DIGIT'
.A
A = 0
YES
NO
CARRY SET
YES
.C
NO
CARRY CLEAR
YES
.B
NO
.A
CARRY ← 0
A ← R3
A ← Ā
A ← A + R6
CARRY SET
YES
NO
.B
A ← 0
R0 ← A
R1 ← A
'CLEAR P.F.'
RET
'INITIALIZE QUOTIENT'
.C
A ← 0
R0 ← A
R1 ← A
SELECT REG. BANK 0
'SAVE T1' AT LOC 20₁₆
R0 ⇐ T1
R1 ⇐ 20₁₆
R2 ⇐ 3
SAVE
'INITIALIZE DIGIT COUNTER'
R4 ⇐ 4
SUBTRACT
'SAVE PARTIAL DIVIDEND'
SELECT REG. BANK 0
R0 ⇐ T1
R1 ⇐ 23₁₆
R2 ⇐ 3
SAVE
SELECT REG. BANK 1
A ← R4
A ← Ā
A ← A + R7
DAA
R4 ← A
A ← R3
A ← Ā
A ← A + R6 + CARRY
DAA
A
A
R3 ← A
R2 ← A
A ← Ā
A ← A + R5 + CARRY
DAA
R2 ← A
CARRY SET
YES
RESTORE
NO
'INCREMENT QUOTIENT'
R1 ← R1 + 1
SUBTRACT
SELECT REG. BANK 0
R0 ⇐ 23₁₆
R1 ⇐ T1
R2 ⇐ 3
SAVE
SHIFT
'SHIFT R2, R3, R4 LEFT ONE BCD DIGIT'
'SHIFT FIRST BYTE'
SELECT REG. BANK 1
A ← R2
A ← A∩F₁₆
SWAP
R2 ← A
R3 ← A
A ← A∩F0₁₆
SWAP
A ← A∪R2
R2 ← A
A ← R3
A ← A∩F₁₆
SWAP
R3 ← A
A ← R4
A ← A∩F0₁₆
SWAP
A ← A∪R3
R3 ← A
A ← R4
A ← A∩F₁₆
SWAP
R4 ← A
SELECT REG. BANK 0
R4 ← R4 - 1
R4 = 0
SHIFT Q
YES
SUB100
'SHIFT R1,R2 (QUOTIENT)' LEFT ONE BCD DIGIT
SHIFT 0
SELECT REG. BANK 1
A ← R0
A ← A∩F₁₆
SWAP
R0 ← A
A ← R1
A ← A∩F0₁₆
SWAP
A ← A∪R0
R0 ← A
A ← R1
A ← A∩F₁₆
SWAP
R1 ← A
SUBTRACT
'SUBTRACT RESULT FROM 100'
SUB 100
SELECT REG. BANK 1
A ← FF₁₆
A ← A + R1
DAA
R1 ← A
A ← EF₁₆
A ← R0 + A + CARRY
DAA
'RESTORE T1'
R0 ← A
SELECT REG. BANK 0
R0 ⇐ 20₁₆
R1 ⇐ T1
R2 ⇐ 3
SAVE
RET
R0 = FROM ADDRESS
R1 = TO ADDRESS
R2 = NO. OF LOCATIONS
SAVE
A ← (R0)
(R1) ← A
R0 ← R0 + 1
R1 ← R1 + 1
R2 ← R2 - 1
R2 = 0
NO
RET
'PERFORMS A DECIMAL ADJUST AS A PART OF BCD SUBTRACTION'
DAA
F1 ← 0
SELECT REG. BANK 0
R2 ← A
A ← PSW
CARRY CLEAR
CNSET
YES
NO
F1 ← F̄1
'TEST AUX. CARRY'
BIT 6 OF A SET
COHECK
NO
ACSET
YES
A ← R2
A ← A + 60
R2 ← A
F1 SET
CSET
YES
A ← R2
A ← A + 60₁₆
R2 ← A
RESTRC
A ← R2
SELECT REG. BANK 1
CARRY ← 0
'RESET CARRY'
F1 SET
NO
OUT
YES
SET C
CARRY ← C̄ĀR̄R̄Ȳ
A ← Ā
RET

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SOFTWARE FLOWCHARTS
SUBROUTINE PFCALC

DESIGNED ... TECHNICAL APPROVAL ...
DRAWN ... SUBMITTED ...
CHECKED ... APPROVED ...
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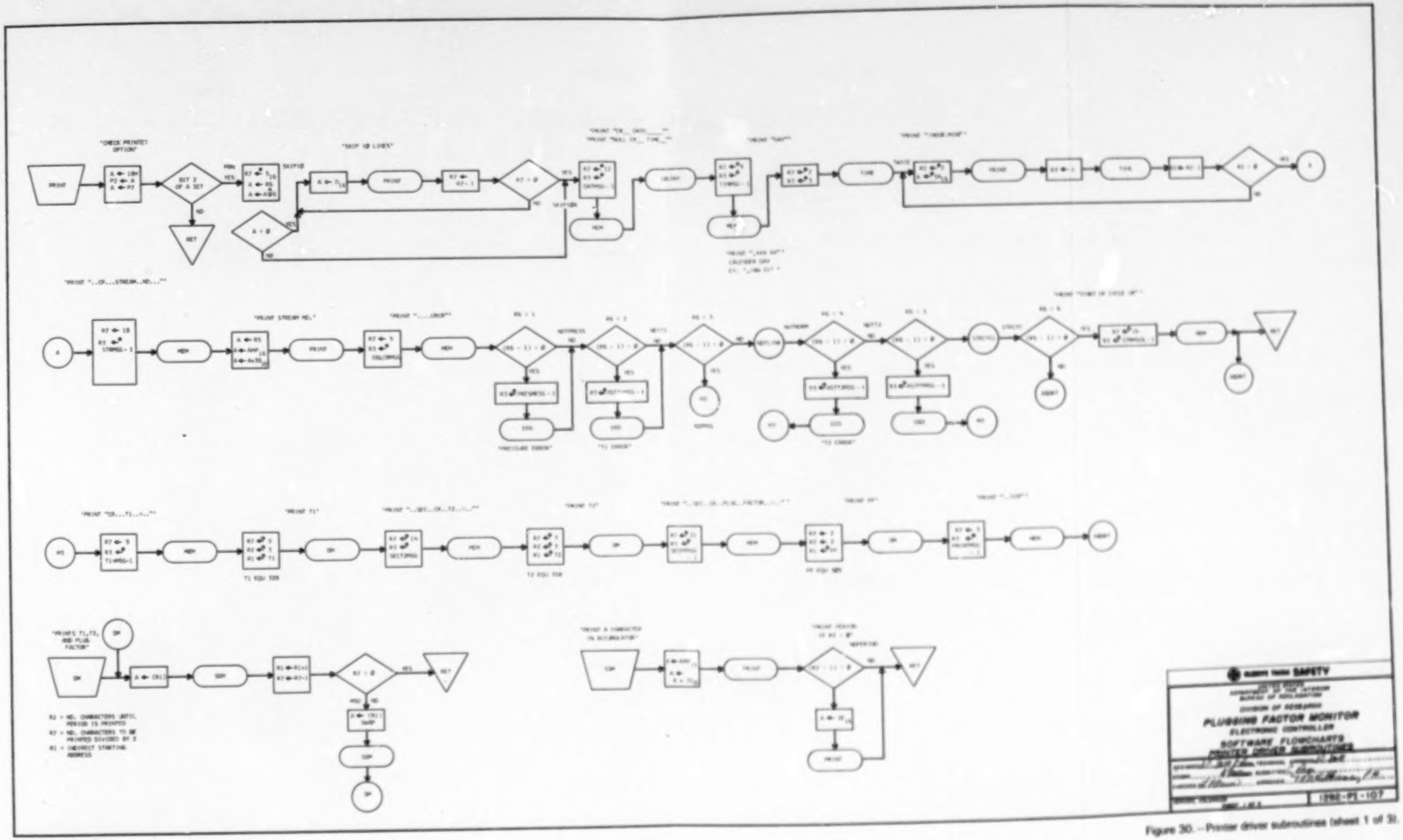
Figure 29.—Subroutine PFCALC.


PRINT
"CHECK PRINTER OPTION"
BIT 2 OF A SET
YES
NO
RET
"SKIP 10 LINES"
A = 0
R7 = 0
MEM
TIME
"PRINT STREAM NO."
"PRESSURE ERROR"
"T1 ERROR"
"T2 ERROR"
T1 EQU 320
T2 EQU 35A
"PRINTS T1,T2, AND PLUG FACTOR"
A ← (R1)
R1 ← R1+1
R7 ← R7-1
R7 = 0
R2 = NO. CHARACTERS UNTIL PERIOD IS PRINTED
R7 = NO. CHARACTERS TO BE PRINTED DIVIDED BY 2
R1 = INDIRECT STARTING ADDRESS
"PRINT A CHARACTER IN ACCUMULATOR"
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PRINTER DRIVER SUBROUTINES
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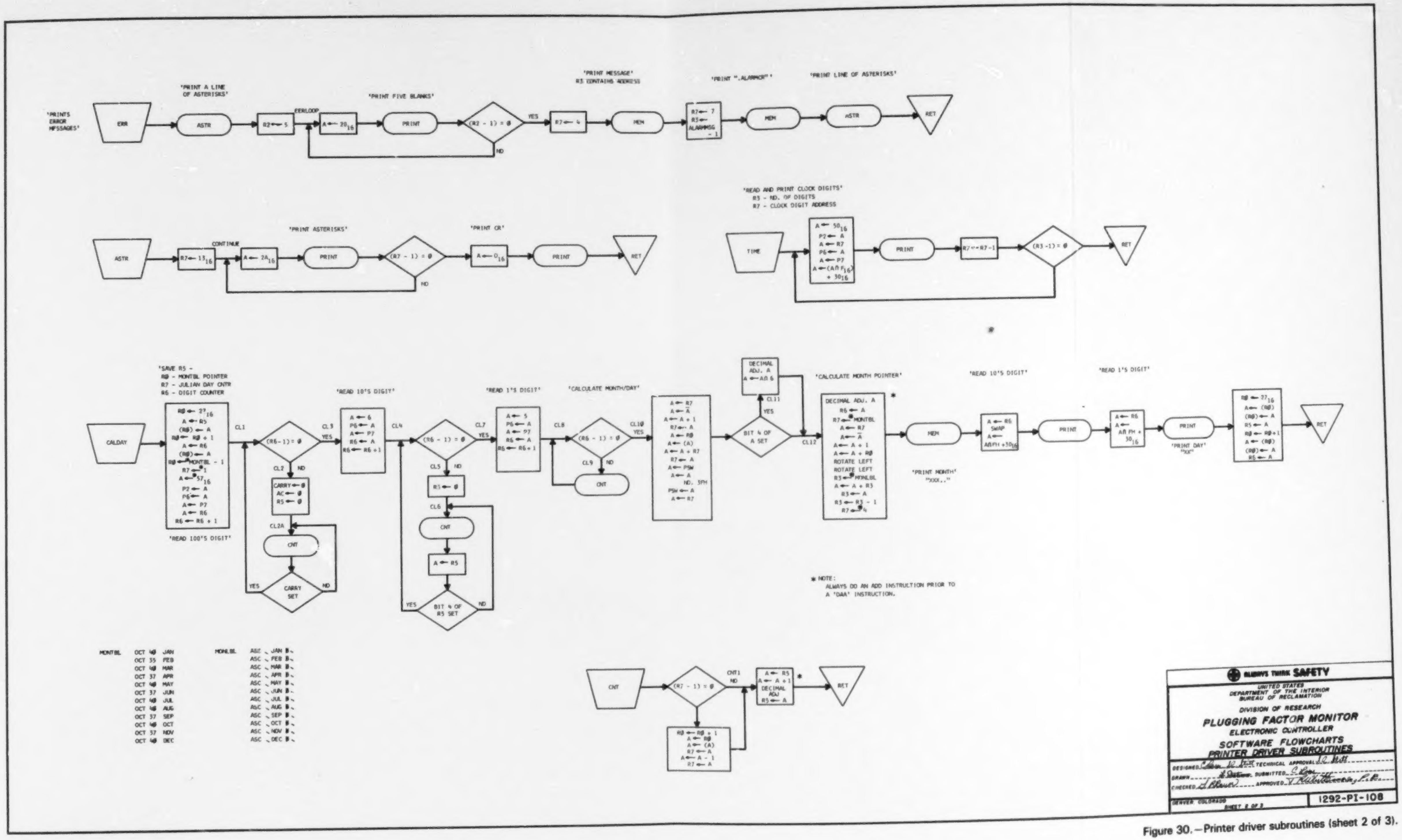
Figure 30. – Printer driver subroutines (sheet 1 of 3).


'PRINTS ERROR MESSAGES'
ERR
'PRINT A LINE OF ASTERISKS'
ASTR
R2 ← 5
EERLOOP
A ← 20_{16}
'PRINT FIVE BLANKS'
PRINT
(R2 - 1) = 0
YES
NO
R7 ← 4
'PRINT MESSAGE' R3 CONTAINS ADDRESS
MEM
R7 ← 7
R3 ← ALARMMSG - 1
'PRINT ".ALARMCR"'
MEM
'PRINT LINE OF ASTERISKS'
ASTR
RET
ASTR
R7 ← 13_{16}
CONTINUE
A ← $2A_{16}$
'PRINT ASTERISKS'
PRINT
(R7 - 1) = 0
NO
'PRINT CR'
A ← 0_{16}
PRINT
RET
'READ AND PRINT CLOCK DIGITS'
R3 - NO. OF DIGITS
R7 - CLOCK DIGIT ADDRESS
TIME
A ← 50_{16}
P2 ← A
A ← R7
P6 ← A
A ← P7
A ← (A ∩ F_{16}) + 30_{16}
PRINT
R7 ← R7-1
(R3 -1) = 0
RET
'SAVE R5 -
R0 - MONTBL POINTER
R7 - JULIAN DAY CNTR
R6 - DIGIT COUNTER
CALDAY
R0 ← 27_{16}
A ← R5
(R0) ← A
R0 ← R0 + 1
A ← R6
(R0) ← A
R0 ← MONTBL - 1
R7 ← 1
A ← 57_{16}
P2 ← A
P6 ← A
A ← P7
A ← R6
R6 ← R6 + 1
'READ 100'S DIGIT'
CL1
(R6-1) = 0
CL2
NO
CARRY ← 0
AC ← 0
R5 ← 0
CL2A
CNT
YES
CARRY SET
NO
CL3
YES
'READ 10'S DIGIT'
A ← 6
P6 ← A
A ← P7
R6 ← A
R6 ← R6 + 1
CL4
(R6 - 1) = 0
CL5
NO
R5 ← 0
CL6
CNT
A ← R5
YES
BIT 4 OF R5 SET
NO
CL7
YES
'READ 1'S DIGIT'
A ← 5
P6 ← A
A ← P7
R6 ← A
R6 ← R6 + 1
CL8
'CALCULATE MONTH/DAY'
(R6 - 1) = 0
CL9
NO
CNT
CL10
YES
A ← R7
A ← $\overline{A}$
A ← A + 1
R7 ← A
A ← R0
A ← (A)
A ← A + R7
R7 ← A
A ← PSW
A ← A
NO. 3FH
PSW ← A
A ← R7
BIT 4 OF A SET
YES
CL11
DECIMAL ADJ. A
A ← A ∩ 6
CL12
'CALCULATE MONTH POINTER'
DECIMAL ADJ. A
R6 ← A
R7 ← MONTBL
A ← R7
A ← $\overline{A}$
A ← A + 1
A ← A + R0
ROTATE LEFT
ROTATE LEFT
R3 ← MONLBL
A ← A + R3
R3 ← A
R3 ← R3 - 1
R7 ← 4
*
MEM
'PRINT MONTH'
"XXX.."
'READ 10'S DIGIT'
A ← R6
SWAP
A ← A ∩ FH + 30_{16}
PRINT
'READ 1'S DIGIT'
A ← R6
A ← A ∩ FH + 30_{16}
PRINT
'PRINT DAY'
"XX"
R0 ← 27_{16}
A ← (R0)
(R0) ← A
R5 ← A
R0 ← R0 + 1
A ← (R0)
(R0) ← A
R6 ← A
RET
CNT
(R7 - 1) = 0
CNT1
NO
R0 ← R0 + 1
A ← R0
A ← (A)
R7 ← A
A ← A - 1
R7 ← A
A ← R5
A ← A + 1
DECIMAL ADJ
R5 ← A
*
RET
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```
MONTBL   OCT 40  JAN          MONLBL   ASC ˽JAN 0˽
         OCT 35  FEB                   ASC ˽FEB 0˽
         OCT 40  MAR                   ASC ˽MAR 0˽
         OCT 37  APR                   ASC ˽APR 0˽
         OCT 40  MAY                   ASC ˽MAY 0˽
         OCT 37  JUN                   ASC ˽JUN 0˽
         OCT 40  JUL                   ASC ˽JUL 0˽
         OCT 40  AUG                   ASC ˽AUG 0˽
         OCT 37  SEP                   ASC ˽SEP 0˽
         OCT 40  OCT                   ASC ˽OCT 0˽
         OCT 37  NOV                   ASC ˽NOV 0˽
         OCT 40  DEC                   ASC ˽DEC 0˽
```

* NOTE:
ALWAYS DO AN ADD INSTRUCTION PRIOR TO A 'DAA' INSTRUCTION.

Figure 30.—Printer driver subroutines (sheet 2 of 3).

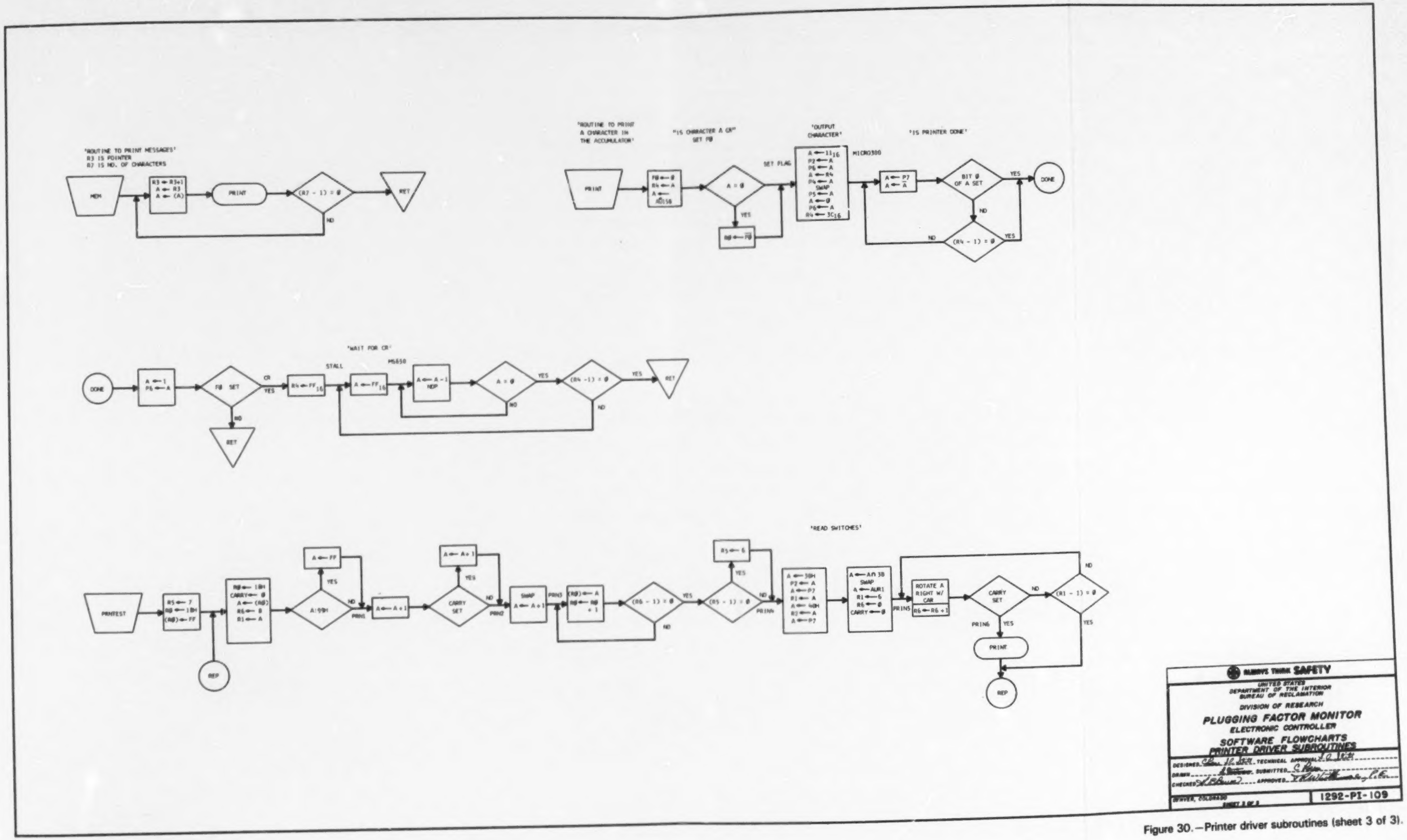
'ROUTINE TO PRINT MESSAGES'
R3 IS POINTER
R7 IS NO. OF CHARACTERS
MEM
R3 ← R3+1
A ← R3
A ← (A)
PRINT
(R7 - 1) = 0
NO
RET
'ROUTINE TO PRINT A CHARACTER IN THE ACCUMULATOR'
PRINT
F0 ← 0
R4 ← A
A ← A0158
"IS CHARACTER A CR" SET F0
A = 0
YES
R0 ← F0
SET FLAG
'OUTPUT CHARACTER'
A ← 11₁₆
P2 ← A
P6 ← A
A ← R4
P4 ← A
SWAP
P5 ← A
A ← 0
P6 ← A
R4 ← 3C16
MICRO300
'IS PRINTER DONE'
A ← P7
A ← Ā
BIT 0 OF A SET
YES
NO
(R4 - 1) = 0
NO
YES
DONE
DONE
A ← 1
P6 ← A
F0 SET
CR
YES
NO
RET
'WAIT FOR CR'
STALL
R4 ← FF16
A ← FF16
MS650
A ← A - 1
NOP
A = 0
YES
NO
(R4 -1) = 0
YES
NO
RET
PRNTEST
R5 ← 7
R0 ← 1BH
(R0) ← FF
REP
R0 ← 1BH
CARRY ← 0
A ← (R0)
R6 ← 8
R1 ← A
A:99H
YES
A ← FF
NO
PRIN1
A ← A+1
CARRY SET
YES
A ← A+1
NO
PRIN2
SWAP
A ← A+1
PRIN3
(R0) ← A
R0 ← R0 + 1
(R6 - 1) = 0
YES
NO
(R5 - 1) = 0
YES
R5 ← 6
NO
PRIN4
'READ SWITCHES'
A ← 3BH
P2 ← A
A ← P7
R1 ← A
A ← 40H
R2 ← A
A ← P7
A ← A∩ 3B
SWAP
A ← AUR1
R1 ← 6
R6 ← 0
CARRY ← 0
PRIN5
ROTATE A RIGHT W/ CAR
R6 ← R6 + 1
CARRY SET
NO
(R1 - 1) = 0
NO
YES
PRIN6
YES
PRINT
REP
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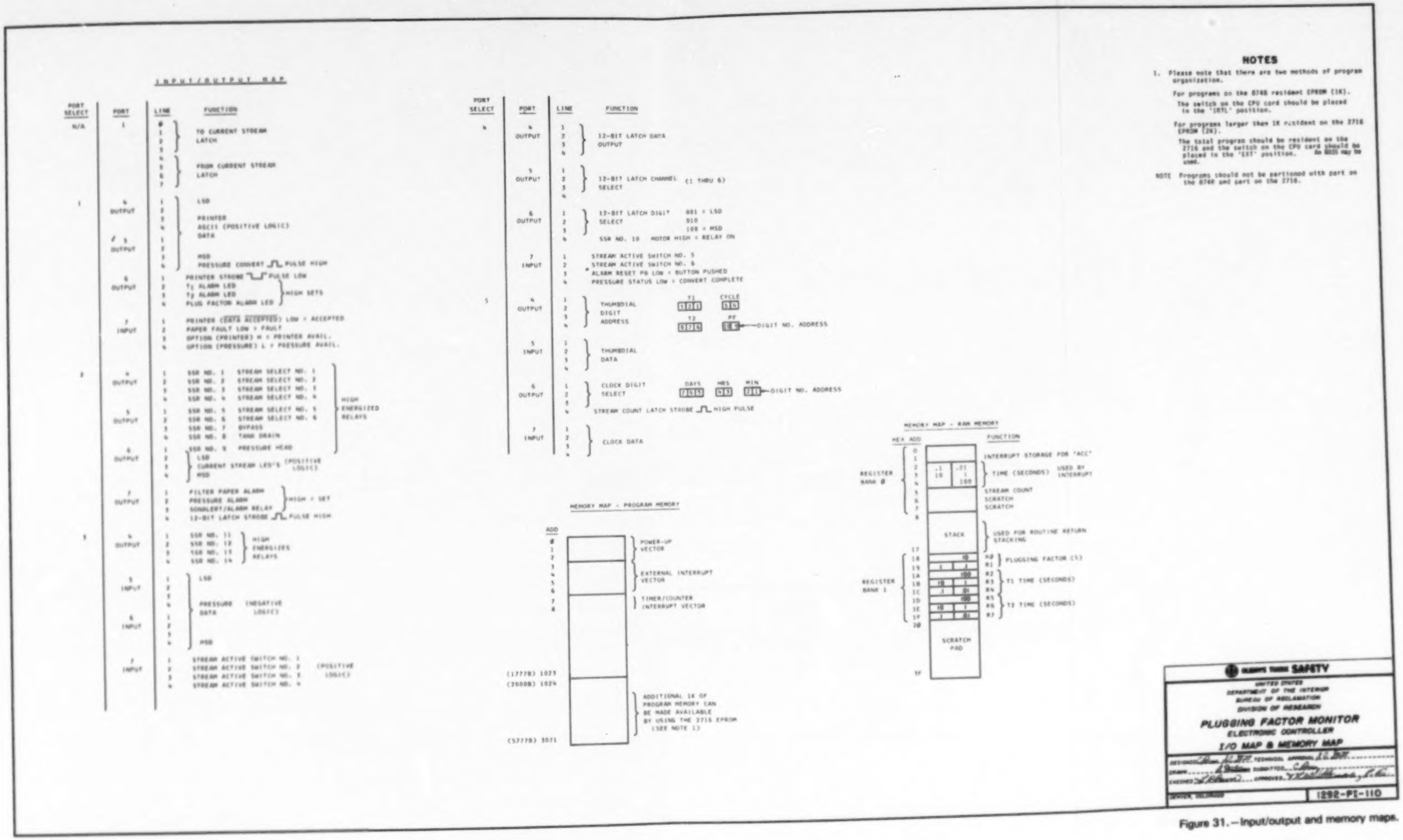
Figure 30.—Printer driver subroutines (sheet 3 of 3).



MEMORY MAP - PROGRAM MEMORY
ADD
0
1
2
3
4
5
6
7
8
(1777O) 1023
(2000O) 1024
(5777O) 3071
POWER-UP VECTOR
EXTERNAL INTERRUPT VECTOR
TIMER/COUNTER INTERRUPT VECTOR
ADDITIONAL 1K OF PROGRAM MEMORY CAN BE MADE AVAILABLE BY USING THE 2716 EPROM (SEE NOTE 1)
MEMORY MAP - RAM MEMORY
HEX ADD
FUNCTION
REGISTER BANK 0
0
1
2
3
4
5
6
7
8
INTERRUPT STORAGE FOR "ACC"
.1
10
.01
1
100
TIME (SECONDS)
USED BY INTERRUPT
STREAM COUNT
SCRATCH
SCRATCH
STACK
USED FOR ROUTINE RETURN STACKING
17
REGISTER BANK 1
18
19
1A
1B
1C
1D
1E
1F
20
R0
R1
R2
R3
R4
R5
R6
R7
PLUGGING FACTOR (%)
T1 TIME (SECONDS)
T2 TIME (SECONDS)
SCRATCH PAD
3F
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I/O MAP & MEMORY MAP
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INPUT/OUTPUT MAP

PORT SELECT	PORT	LINE	FUNCTION
N/A	1	0	TO CURRENT STREAM LATCH
		1	
		2	
		3	
		4	FROM CURRENT STREAM LATCH
		5	
		6	
		7	
1	4 OUTPUT	1	LSD
		2	PRINTER
		3	ASCII (POSITIVE LOGIC)
		4	DATA
	5 OUTPUT	1	
		2	
		3	MSD
		4	PRESSURE CONVERT ⎍ PULSE HIGH
	6 OUTPUT	1	PRINTER STROBE ⊔ PULSE LOW
		2	T1 ALARM LED (HIGH SETS)
		3	T2 ALARM LED (HIGH SETS)
		4	PLUG FACTOR ALARM LED (HIGH SETS)
	7 INPUT	1	PRINTER (DATA ACCEPTED) LOW = ACCEPTED
		2	PAPER FAULT LOW = FAULT
		3	OPTION (PRINTER) H = PRINTER AVAIL.
		4	OPTION (PRESSURE) L = PRESSURE AVAIL.
2	4 OUTPUT	1	SSR NO. 1 STREAM SELECT NO. 1 (HIGH ENERGIZED RELAYS)
		2	SSR NO. 2 STREAM SELECT NO. 2
		3	SSR NO. 3 STREAM SELECT NO. 3
		4	SSR NO. 4 STREAM SELECT NO. 4
	5 OUTPUT	1	SSR NO. 5 STREAM SELECT NO. 5
		2	SSR NO. 6 STREAM SELECT NO. 6
		3	SSR NO. 7 BYPASS
		4	SSR NO. 8 TANK DRAIN
	6 OUTPUT	1	SSR NO. 9 PRESSURE HEAD
		2	LSD
		3	CURRENT STREAM LED'S (POSITIVE LOGIC)
		4	MSD
	7 OUTPUT	1	FILTER PAPER ALARM (HIGH = SET)
		2	PRESSURE ALARM (HIGH = SET)
		3	SONALERT/ALARM RELAY (HIGH = SET)
		4	12-BIT LATCH STROBE ⎍ PULSE HIGH
3	4 OUTPUT	1	SSR NO. 11 (HIGH ENERGIZES RELAYS)
		2	SSR NO. 12
		3	SSR NO. 13
		4	SSR NO. 14
	5 INPUT	1	LSD
		2	
		3	
		4	PRESSURE DATA (NEGATIVE LOGIC)
	6 INPUT	1	
		2	
		3	
		4	MSD
	7 INPUT	1	STREAM ACTIVE SWITCH NO. 1 (POSITIVE LOGIC)
		2	STREAM ACTIVE SWITCH NO. 2
		3	STREAM ACTIVE SWITCH NO. 3
		4	STREAM ACTIVE SWITCH NO. 4

PORT SELECT	PORT	LINE	FUNCTION
4	4 OUTPUT	1	12-BIT LATCH DATA OUTPUT
		2	
		3	
		4	
	5 OUTPUT	1	12-BIT LATCH CHANNEL SELECT (1 THRU 6)
		2	
		3	
		4	
	6 OUTPUT	1	12-BIT LATCH DIGIT SELECT 001 = LSD 010 100 = MSD
		2	
		3	
		4	SSR NO. 10 MOTOR HIGH = RELAY ON
	7 INPUT	1	STREAM ACTIVE SWITCH NO. 5
		2	STREAM ACTIVE SWITCH NO. 6
		3	ALARM RESET PB LOW = BUTTON PUSHED
		4	PRESSURE STATUS LOW = CONVERT COMPLETE
5	4 OUTPUT	1	THUMBDIAL DIGIT ADDRESS T1 3 2 1 CYCLE 5 4 T2 8 7 6 PF 10 9 ← DIGIT NO. ADDRESS
		2	
		3	
		4	
	5 INPUT	1	THUMBDIAL DATA
		2	
		3	
		4	
	6 OUTPUT	1	CLOCK DIGIT SELECT DAYS 7 6 5 HRS 4 3 MIN 2 1 ← DIGIT NO. ADDRESS
		2	
		3	
		4	STREAM COUNT LATCH STROBE ⎍ HIGH PULSE
	7 INPUT	1	CLOCK DATA
		2	
		3	
		4	

NOTES

1. Please note that there are two methods of program organization.

   For programs on the 8748 resident EPROM (1K).

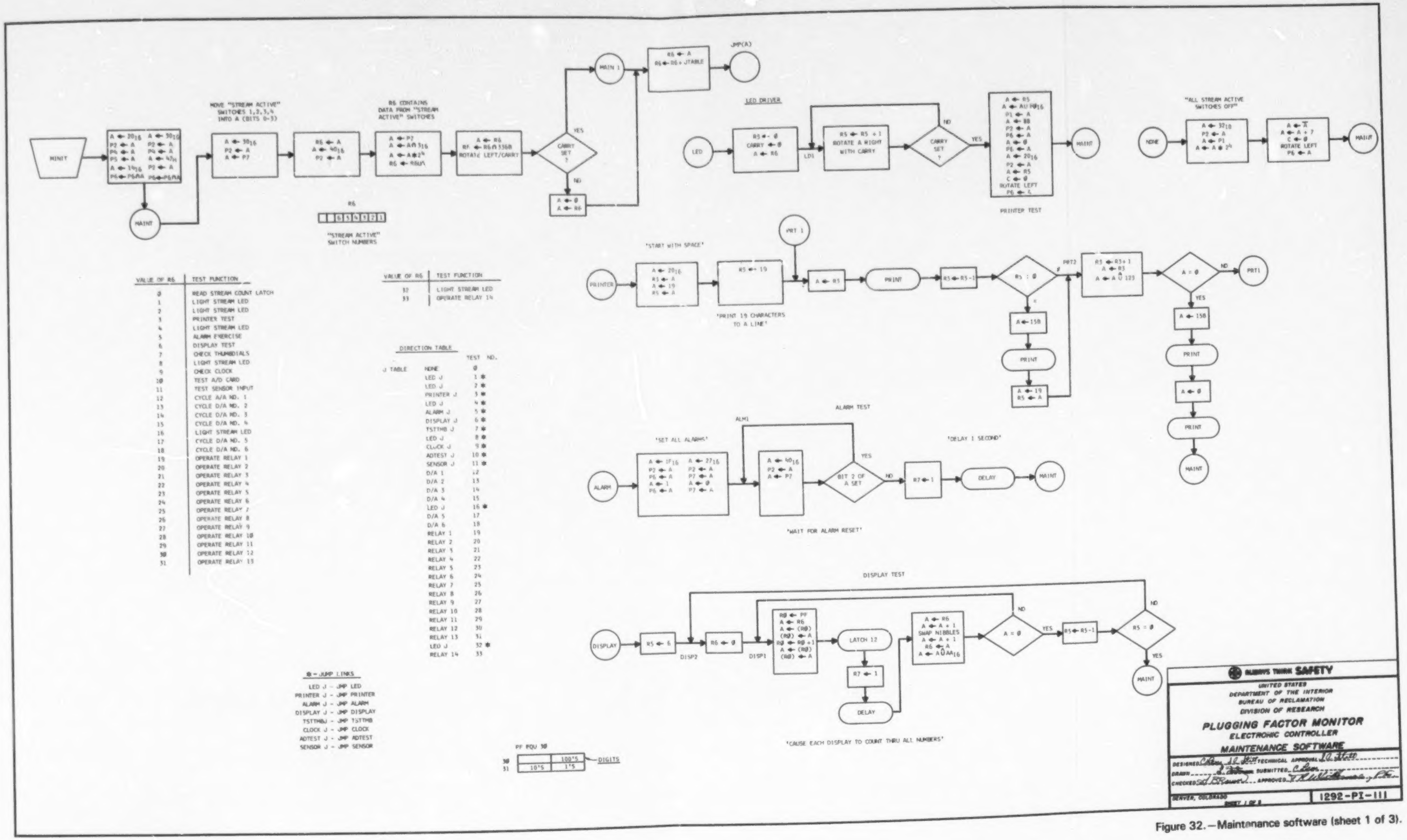
   The switch on the CPU card should be placed in the 'INTL' position.

   For programs larger than 1K resident on the 2716 EPROM (2K).

   The total program should be resident on the 2716 and the switch on the CPU card should be placed in the 'EXT' position. An 8035 may be used.

NOTE Programs should not be partitioned with part on the 8748 and part on the 2716.

Figure 31.—Input/output and memory maps.


MINIT
A ← 20_{16} P2 ← A P4 ← A P5 ← A A ← 14_{16} P6 ← P6∩A
A ← 30_{16} P2 ← A P4 ← A A ← 47_{H} P2 ← A P6 ← P6∩A
MAINT
MOVE "STREAM ACTIVE" SWITCHES 1,2,3,4 INTO A (BITS 0-3)
A ← 30_{16} P2 ← A A ← P7
R6 ← A A ← 40_{16} P2 ← A
R6 CONTAINS DATA FROM "STREAM ACTIVE" SWITCHES
A ← P7 A ← A∩3_{16} A ← A∗2^4 R6 ← R6∪A
A ← R6 R6 ← R6∩336B ROTATE LEFT/CARRY
CARRY SET ?
YES
NO
A ← 0 A ← R6
MAIN 1
R6 ← A R6 ← R6 + JTABLE
JMP(A)
R6
6 5 4 3 2 1
"STREAM ACTIVE" SWITCH NUMBERS
LED DRIVER
LED
R5 ← 0 CARRY ← 0 A ← R6
LD1
R5 ← R5 + 1 ROTATE A RIGHT WITH CARRY
CARRY SET ?
NO
YES
A ← R5 A ← A∪ $F0_{16}$ P1 ← A A ← 8B P2 ← A P6 ← A A ← 0 P6 ← A A ← 20_{16} P2 ← A A ← R5 C ← 0 ROTATE LEFT P6 ← 4
MAINT
"ALL STREAM ACTIVE SWITCHES OFF"
NONE
A ← 32_{10} P2 ← A A ← P1 A ← A ∗ 2^4
A ← $\overline{A}$ A ← A + 7 C ← 0 ROTATE LEFT P6 ← A
MAINT
PRINTER TEST
'START WITH SPACE'
PRINTER
A ← 20_{16} R3 ← A A ← 19 R5 ← A
R5 ← 19
'PRINT 19 CHARACTERS TO A LINE'
PRT 1
A ← R3
PRINT
R5 ← R5-1
R5 : 0
≠
=
A ← 158
PRINT
A ← 19 R5 ← A
PRT2
R3 ← R3+ 1 A ← R3 A ← A $\hat{\cup}$ 123
A = 0
NO
PRT1
YES
A ← 158
PRINT
A ← 0
PRINT
MAINT
ALARM TEST
'SET ALL ALARMS'
ALARM
A ← $1F_{16}$ P2 ← A P6 ← A A ← 1 P6 ← A
A ← 27_{16} P2 ← A P7 ← A A ← 0 P7 ← A
ALM1
A ← 40_{16} P2 ← A A ← P7
BIT 2 OF A SET
YES
NO
'WAIT FOR ALARM RESET'
'DELAY 1 SECOND'
R7 ← 1
DELAY
MAINT
DISPLAY TEST
DISPLAY
R5 ← 6
DISP2
R6 ← 0
DISP1
R0 ← PF A ← R6 A ← (R0) (R0) ← A R0 ← R0 + 1 A ← (R0) (R0) ← A
LATCH 12
R7 ← 1
DELAY
A ← R6 A ← A + 1 SWAP NIBBLES A ← A + 1 R6 ← A A ← A $\hat{\cup}$ AA_{16}
A = 0
NO
YES
R5 ← R5-1
R5 = 0
NO
YES
MAINT
'CAUSE EACH DISPLAY TO COUNT THRU ALL NUMBERS'
PF EQU 30
30
31
100'S
10'S
1'S
DIGITS

VALUE OF R6	TEST FUNCTION
0	READ STREAM COUNT LATCH
1	LIGHT STREAM LED
2	LIGHT STREAM LED
3	PRINTER TEST
4	LIGHT STREAM LED
5	ALARM EXERCISE
6	DISPLAY TEST
7	CHECK THUMBDIALS
8	LIGHT STREAM LED
9	CHECK CLOCK
10	TEST A/D CARD
11	TEST SENSOR INPUT
12	CYCLE A/A NO. 1
13	CYCLE D/A NO. 2
14	CYCLE D/A NO. 3
15	CYCLE D/A NO. 4
16	LIGHT STREAM LED
17	CYCLE D/A NO. 5
18	CYCLE D/A NO. 6
19	OPERATE RELAY 1
20	OPERATE RELAY 2
21	OPERATE RELAY 3
22	OPERATE RELAY 4
23	OPERATE RELAY 5
24	OPERATE RELAY 6
25	OPERATE RELAY 7
26	OPERATE RELAY 8
27	OPERATE RELAY 9
28	OPERATE RELAY 10
29	OPERATE RELAY 11
30	OPERATE RELAY 12
31	OPERATE RELAY 13

VALUE OF R6	TEST FUNCTION
32	LIGHT STREAM LED
33	OPERATE RELAY 14

DIRECTION TABLE

		TEST NO.
J TABLE	NONE	0
	LED J	1 ✱
	LED J	2 ✱
	PRINTER J	3 ✱
	LED J	4 ✱
	ALARM J	5 ✱
	DISPLAY J	6 ✱
	TSTTMB J	7 ✱
	LED J	8 ✱
	CLOCK J	9 ✱
	ADTEST J	10 ✱
	SENSOR J	11 ✱
	D/A 1	12
	D/A 2	13
	D/A 3	14
	D/A 4	15
	LED J	16 ✱
	D/A 5	17
	D/A 6	18
	RELAY 1	19
	RELAY 2	20
	RELAY 3	21
	RELAY 4	22
	RELAY 5	23
	RELAY 6	24
	RELAY 7	25
	RELAY 8	26
	RELAY 9	27
	RELAY 10	28
	RELAY 11	29
	RELAY 12	30
	RELAY 13	31
	LED J	32 ✱
	RELAY 14	33

✱ – JUMP LINKS

LED J – JMP LED
PRINTER J – JMP PRINTER
ALARM J – JMP ALARM
DISPLAY J – JMP DISPLAY
TSTTMBJ – JMP TSTTMB
CLOCK J – JMP CLOCK
ADTEST J – JMP ADTEST
SENSOR J – JMP SENSOR

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MAINTENANCE SOFTWARE

DESIGNED TECHNICAL APPROVAL
DRAWN SUBMITTED
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DENVER, COLORADO
SHEET 1 OF 3
1292-PI-111

Figure 32.—Maintenance software (sheet 1 of 3).

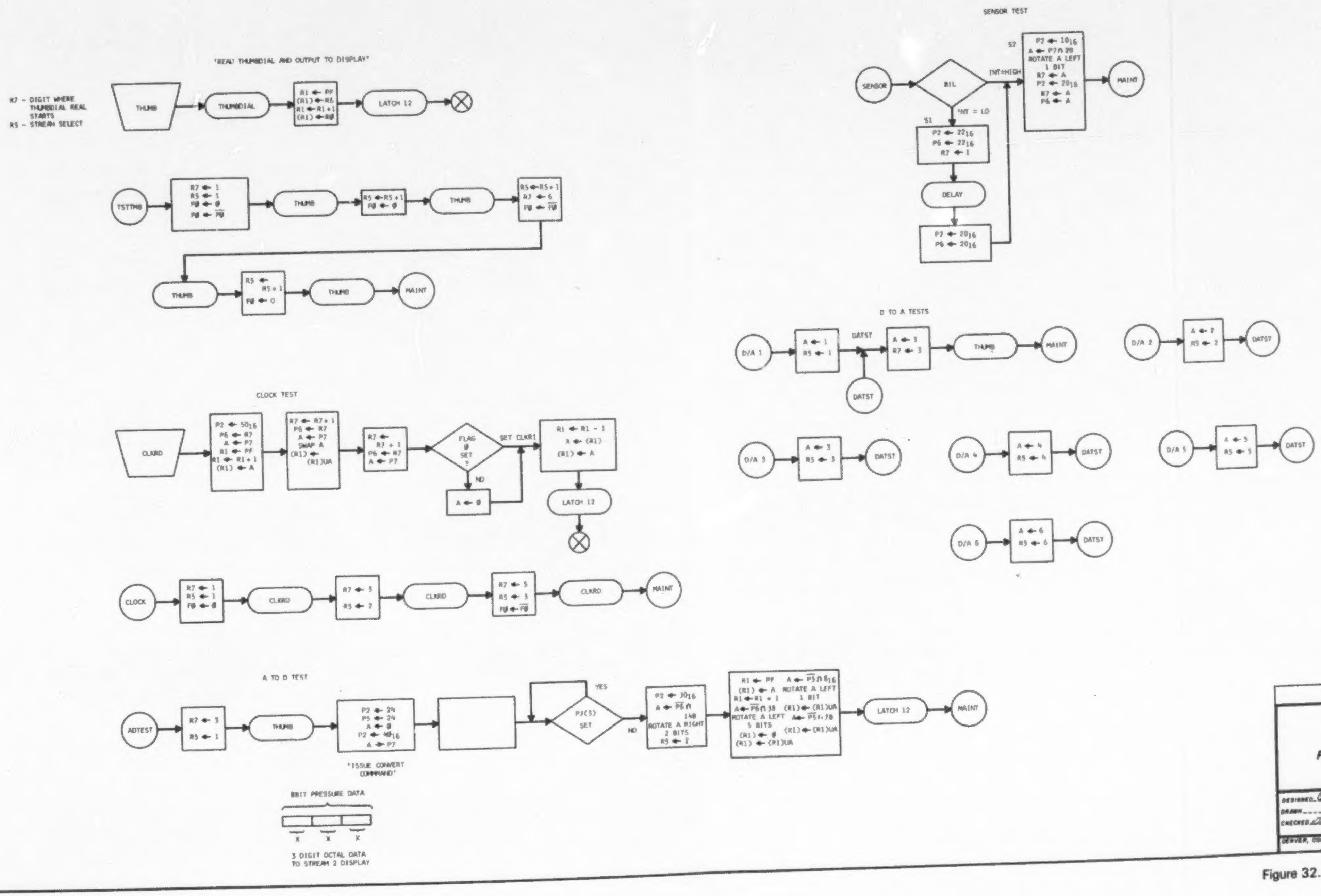
'REAL THUMBDIAL AND OUTPUT TO DISPLAY'
R7 - DIGIT WHERE THUMBDIAL REAL STARTS
R5 - STREAM SELECT
THUMB
THUMBDIAL
R1 ← PF
(R1) ← R6
R1 ← R1 + 1
(R1) ← R0
LATCH 12
TSTTMB
R7 ← 1
R5 ← 1
F0 ← 0
F0 ← $\overline{F0}$
THUMB
R5 ← R5 + 1
F0 ← 0
THUMB
R5 ← R5 + 1
R7 ← 6
F0 ← $\overline{F0}$
THUMB
R5 ← R5 + 1
F0 ← 0
THUMB
MAINT
SENSOR TEST
SENSOR
BIL
INT=HIGH
INT = LO
S1
P2 ← 22_{16}
P6 ← 22_{16}
R7 ← 1
DELAY
P2 ← 20_{16}
P6 ← 20_{16}
S2
P2 ← 10_{16}
A ← P7∩2B
ROTATE A LEFT 1 BIT
R7 ← A
P2 ← 20_{16}
R7 ← A
P6 ← A
MAINT
D TO A TESTS
D/A 1
A ← 1
R5 ← 1
DATST
DATST
A ← 3
R7 ← 3
THUMB
MAINT
D/A 2
A ← 2
R5 ← 2
DATST
D/A 3
A ← 3
R5 ← 3
DATST
D/A 4
A ← 4
R5 ← 4
DATST
D/A 5
A ← 5
R5 ← 5
DATST
D/A 6
A ← 6
R5 ← 6
DATST
CLOCK TEST
CLKRD
P2 ← 50_{16}
P6 ← R7
A ← P7
R1 ← PF
R1 ← R1 + 1
(R1) ← A
R7 ← R7 + 1
P6 ← R7
A ← P7
SWAP A
(R1) ← (R1)UA
R7 ← R7 + 1
P6 ← R7
A ← P7
FLAG 0 SET ?
SET CLKR1
NO
A ← 0
R1 ← R1 - 1
A ← (R1)
(R1) ← A
LATCH 12
CLOCK
R7 ← 1
R5 ← 1
F0 ← 0
CLKRD
R7 ← 3
R5 ← 2
CLKRD
R7 ← 5
R5 ← 3
F0 ← $\overline{F0}$
CLKRD
MAINT
A TO D TEST
ADTEST
R7 ← 3
R5 ← 1
THUMB
P2 ← 24
P5 ← 24
A ← 0
P2 ← 40_{16}
A ← P7
'ISSUE CONVERT COMMAND'
P7(3) SET
YES
NO
P2 ← 30_{16}
A ← $\overline{P6}$ ∩ 148
ROTATE A RIGHT 2 BITS
R5 ← 2
R1 ← PF
(R1) ← A
R1 ← R1 + 1
A ← $\overline{P6}$ ∩ 38
ROTATE A LEFT 5 BITS
(R1) ← 0
(R1) ← (R1)UA
A ← $\overline{P5}$ ∩ 8_{16}
ROTATE A LEFT 1 BIT
(R1) ← (R1)UA
A ← $\overline{P5}$ ∩ 78
(R1) ← (R1)UA
LATCH 12
MAINT
8BIT PRESSURE DATA
X
X
X
3 DIGIT OCTAL DATA TO STREAM 2 DISPLAY

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Figure 32.—Maintenance software (sheet 2 of 3).

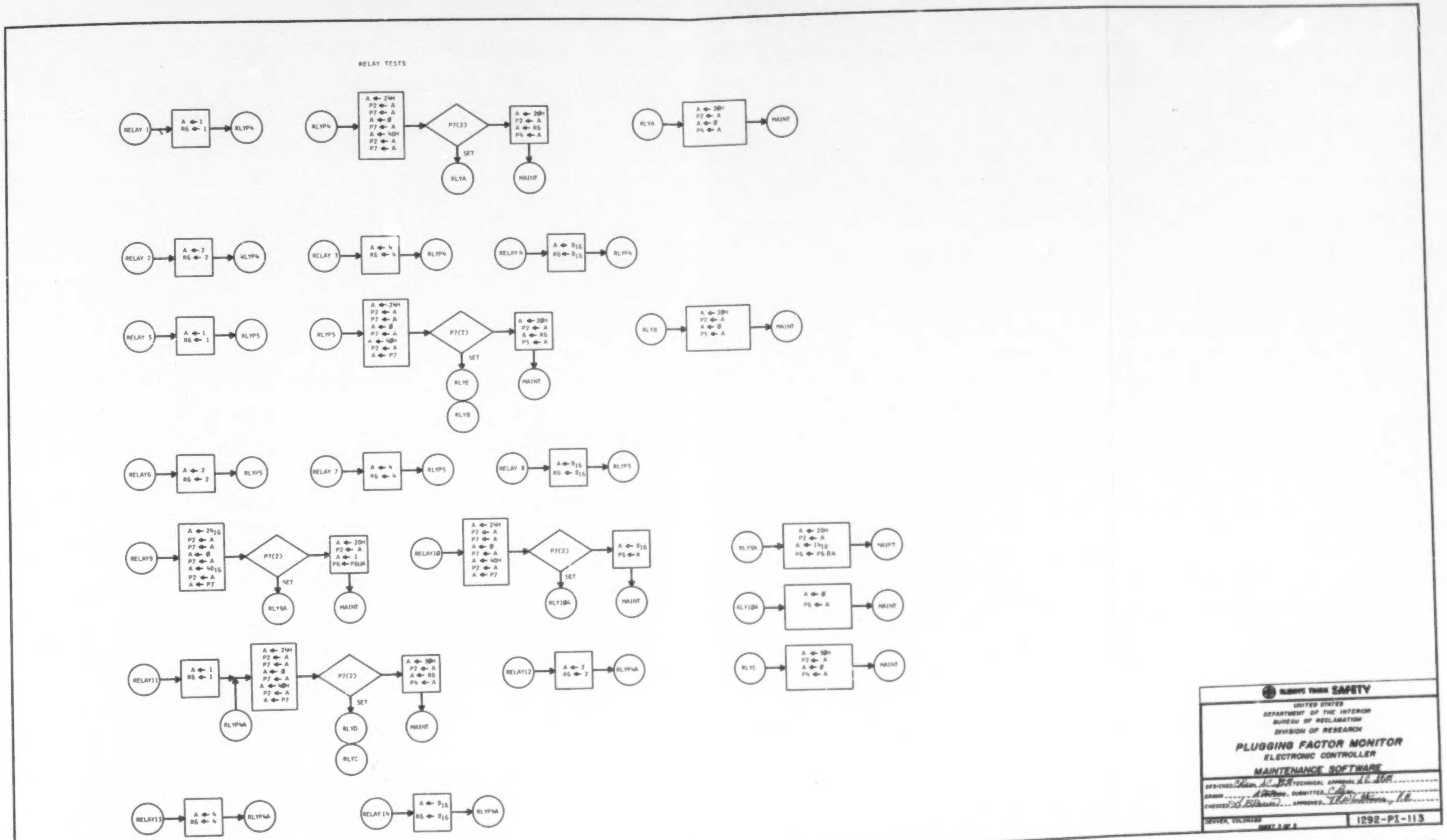
RELAY TESTS
RELAY 1
A ← 1
R6 ← 1
RLYP4
RLYP4
A ← 24H
P2 ← A
P7 ← A
A ← 0
P7 ← A
A ← 40H
P2 ← A
P7 ← A
P7(2)
SET
RLYA
A ← 20H
P2 ← A
A ← R6
P4 ← A
MAINT
RLYA
A ← 20H
P2 ← A
A ← 0
P4 ← A
MAINT
RELAY 2
A ← 2
R6 ← 2
RLYP4
RELAY 3
A ← 4
R6 ← 4
RLYP4
RELAY 4
A ← 8_16
R6 ← 8_16
RLYP4
RELAY 5
A ← 1
R6 ← 1
RLYP5
RLYP5
A ← 24H
P2 ← A
P7 ← A
A ← 0
P7 ← A
A ← 40H
P2 ← A
A ← P7
P7(2)
SET
RLYE
RLYB
A ← 20H
P2 ← A
A ← R6
P5 ← A
MAINT
RLYB
A ← 20H
P2 ← A
A ← 0
P5 ← A
MAINT
RELAY6
A ← 2
R6 ← 2
RLYP5
RELAY 7
A ← 4
R6 ← 4
RLYP5
RELAY 8
A ← 8_16
R6 ← 8_16
RLYP5
RELAY9
A ← 24_16
P2 ← A
P7 ← A
A ← 0
P7 ← A
A ← 40_16
P2 ← A
A ← P7
P7(2)
SET
RLY9A
A ← 20H
P2 ← A
A ← 1
P6 ← P6UA
MAINT
RELAY10
A ← 24H
P2 ← A
P7 ← A
A ← 0
P7 ← A
A ← 40H
P2 ← A
A ← P7
P7(2)
SET
RLY10A
A ← 8_16
P6 ← A
MAINT
RLY9A
A ← 20H
P2 ← A
A ← 14_10
P6 ← P6 AA
MAIPT
RLY10A
A ← 0
P6 ← A
MAINT
RELAY11
A ← 1
R6 ← 1
RLYP4A
A ← 24H
P2 ← A
P7 ← A
A ← 0
P7 ← A
A ← 40H
P2 ← A
A ← P7
P7(2)
SET
RLYD
RLYC
A ← 30H
P2 ← A
A ← R6
P4 ← A
MAINT
RELAY12
A ← 2
R6 ← 2
RLYP4A
RLYC
A ← 30H
P2 ← A
A ← 0
P4 ← A
MAINT
RELAY13
A ← 4
R6 ← 4
RLYP4A
RELAY 14
A ← 8_16
R6 ← 8_16
RLYP4A
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Figure 32.—Maintenance software (sheet 3 of 3).

APPENDIX A

OPERATIONS MANUAL

APPENDIX A
OPERATIONS MANUAL

INTRODUCTION

Each PFM (plugging factor monitor) consists of three separate pieces of equipment. The tester unit contains the Millipore tape, tape drive mechanism, flow rate measuring system, and solenoid valves. The sample point selector booster pump contains solenoid valves and the system pump. The electrical (control) unit contains the microprocessor, solid state relays, and a-c power to connect to the external units. The purpose of this manual is to explain the operation of the control unit.

CONTROL UNIT

Displays

There are two types of displays located on the front panel of the control unit. The plugging factor display (red) indicates the plugging factor in percent for each stream, and the current time and day display (yellow) indicates the Julian day and local time. The day and time display may be set by pushing and then releasing the appropriate pushbutton located below the displayed function (day, hour, minute).

Stream Select Switches

The streat select switches are located on the front panel of the control unit. There are six toggle-type switches numbered 1 through 6, and above each switch is a green LED. When a switch is placed in the active (up) position, the LED above that switch lights up to indicate the stream is active. The control unit will then cycle through the active streams taking plugging factor measurements.

Thumbdial Switches

Four thumbdial switches are located on the front panel of the control unit: one each for the T1 and T2 limits, which are adjustable from 0 to 299 seconds; one for the plugging factor limit, which is adjustable from 0 to 99 percent; and one for the cycle time select, which is adjustable from 0 to 99 minutes. The unit will alarm if a limit is exceeded on T1, T2, or the plugging factor. The cycle time adjustment allows the operator to set the time, in minutes, between the T1 and T2 measurements.

Status Lights

The green LED status lights located on the front panel of the control unit indicate which stream has been activated. The red LED status lights indicate which stream is presently being sampled by the PFM.

Alarms

There are three types of alarm indications for the PFM: audible, LED, and remote. The LED alarm indicators are located on the front panel of the control unit. The audible alarm is activated for any alarm. This audible alarm may be disabled by placing the alarm switch in the OFF (down) position. For power-up, T1 limit, T2 limit, plugging factor limit, low pressure, breakage, or nonadvance of the filter tape, the associated yellow LED alarm is activated. Remote alarm annunciation is available on the back panel of the control unit. An alarm test switch is provided to manually test this alarm. The output consists of a dry contact which is closed for any alarm condition. Pressing the alarm reset button resets all alarm LED's, the audible alarm, and the remote alarms.

Alarm Definitions

Plugging Factor Alarm.—Indicates that the measured plugging factor for the selected stream exceeded the plugging factor limit thumbdial setting. Check the printer record for reasonable T1 and T2 measurements.

T1 Alarm.—Indicates that the T1 time measurement exceeded the thumbdial setting. Check the printer record for a reasonable T1 measurement.

T2 Alarm.—Indicates that the T2 time measurement exceeded the thumbdial setting. Check the printer record for a reasonable T2 measurement.

Filter Paper Alarm.—Indicates the paper is not advancing properly through the tester unit. Check for paper breaks and paper supply depletion. If either of these conditions exist, consult the "Corrective Action" section of this manual.

If the paper is not the problem, lift the spring tension roller on the paper motor and try to feed the paper by hand.

Pressure Alarm.—Indicates that the water pressure to the tester unit is not within the designated limits. Check the pressure. Also, this alarm may activate during the T2 measurements if it takes longer than 20 seconds for the water level to reach the low probe.

If any of these alarms persist, consult the "Corrective Action" section of this manual.

Reset System

The system may be reset by pressing the "System Reset" button located on the front panel of the control unit. Pressing this button stops all operations, clears all plugging factor displays, resets all solenoid valves, and starts normal operation at the last selected active stream.

System Battery Backup

Battery power is provided for maintaining the time, plugging factor measurements, and the present selected stream in operation if there is a loss of a-c power. The battery backup may be disabled by placing the battery backup switch in the OFF position. When the system is operating normally with this switch in the ON position, the battery is being trickle charged.

Printer Operation

The printer provided is a 20-character, alphanumeric, thermo-type printer that is located on the front panel of the control unit. A red light indicates when a-c power is being supplied. The knurl knob located on the front of the printer locks and unlocks the print unit in the print holder. The feed switch feeds paper out of the printer. To change paper in the printer, refer to the manual provided. During operation of the PFM, the printer can provide six different messages. At the beginning of each message, the printer will always provide calendar date (month, day), current time (Julian day, hour, minute), and the current stream operating. The format of the time and stream data is:

```
DATE      JAN 29
TIME      029:13:51
STREAM    NO. 1
```

The format of the start of cycle message is:

```
START OF CYCLE
```

This message occurs at the beginning of every plugging factor measurement cycle. The recorded time that this message occurs, together with the selected cycle time, can be used to determine the time left in the present measurement cycle.

The format of the T1 alarm message is:

```
****************************
          T1 ALARM
****************************
```

This message occurs when measurement time T1 exceeds the thumbdial selected limit. If the alarm occurs, the cycle is aborted and the control unit begins measurement on the next selected active stream.

The format of the pressure alarm message is:

```
****************************
         PRES ALARM
****************************
```

This message occurs when time measurements T1 or T2 cannot be completed because the water pressure in the tester unit is incorrect. A pressure transducer is used to measure this pressure. This alarm will also occur if more than 20 seconds pass before the water reaches the low probe in the measurement tank while attempting to measure T1 or T2.

The format of the T2 alarm message is:

```
****************************
          T2 ALARM
****************************

T1            =  010.12 SEC
T2            =  132.34 SEC
PLUG FACTOR   =  92.4%
```

This message occurs when measurement time T2 exceeds the thumbdial selected limit. Note that when this alarm occurs, the measurements for T1, T2, and the plugging factor are recorded. In the example format shown, the T2 limit was set at 120 seconds.

The format of the plugging factor alarm message is:

```
****************************
          PF ALARM
****************************

     T1           = 009.84 SEC
     T2           = 100.00 SEC
     PLUG FACTOR  = 90.2%
```

This message occurs when the plugging factor measured exceeds the thumbdial selected limit. Note that the measurements for T1, T2, and the plugging factor are recorded. In the example format shown, the plugging factor limit was set at 85 percent.

The printer output messages for a normal plugging factor measurement are shown in the following example format:

```
     DATE         JAN 29
     TIME         029:13:42
     STREAM       NO. 5

          START OF CYCLE

     DATE         JAN 29
     TIME         029:13:51
     STREAM       NO. 5

     T1           = 010.12 SEC
     T2           = 132.34 SEC
     PLUG FACTOR  = 92.4%
```

In this example, the cycle started as 13:42 (1:42 p.m.) and ended at 13:51 (1:51 p.m.). The measurement was taken on stream five, and the measurements for T1, T2, and the plugging factor were as shown.

Power-Up

Power-up is accomplished by initially making sure that the stream select switches located on the front panel are in the OFF (down) position, and then plugging the unit into any convenient a-c outlet. The front panel should now have various indications. The alarm section should indicate all alarms, and they should be reset by pressing the alarm reset pushbutton. The clock display should be indicating the current day, hour, and minute; reset if incorrect. The plugging factor displays should indicate the last measured plugging factor in all displays; refer to "Reset System" section of this manual to reset displays. Check battery backup switch to see that it is in the ON (up) position. Place the audible alarm switch in the ON (up) position. The system is now ready for normal operation.

Begin operation by selecting the T1, T2, and plugging factor limits and the desired cycle time by using the front panel thumbdials. Then select the streams to be activated. The control unit will now begin normal operation.

Power-Down

Power-down is accomplished by simply unplugging the a-c power cord. Please note that if the unit goes through a power-down/power-up cycle, all alarms will always be set on power-up. The control unit will continue to operate following the power-up; however, the alarms must be reset to have complete normal operation. If the unit is to be powered-down for an extended time, turn the battery backup switch to OFF to save the control unit battery.

TESTER UNIT

The Millipore tape is manually threaded onto the tape feed spool located on the tester unit. The tape should be threaded on the spool to feed in a clockwise direction. Marks are provided on the tape feed guides to allow alinement of tape on the pressure head block.

TROUBLESHOOTING

Phone Numbers

John Hodgson, Denver Federal Center, 303-234-3012
Gil Brown, Denver Federal Center, 303-234-3011

Corrective Action

Millipore Tape.—In case of tape breakage or an empty tape spool, the filter paper alarm should occur. Reload the tester unit with filter paper and aline the paper properly. Reset the filter paper alarm and check to see that the paper advances properly. If alarm continues and paper will not advance, check for binding of the paper.

Printer Paper.—If printer malfunctions or is out of paper, disconnect the printer from the a-c outlet located in the rear of the control unit. Unlock the printer using the knurl knob on the front of the printer and gently pull forward until printer is clear of printer holder. Perform corrective action as necessary, i.e., change paper or change print unit.

Control Unit.—If a malfunction occurs or alarms persist with the control unit, contact local maintenance personnel to run maintenance checks.

MAINTENANCE AND TESTING

Control Unit Testing

Power-down the control unit. The control unit testing may be accomplished by inserting the ROM (Read Only Memory) chip labeled PFM MAINTENANCE into the CPU No. 1 board located in the rear of the control unit slot J31. Remove the board from that slot. After inserting the ROM into the ejection type socket of the card, place the toggle switch, which is located next to the ejection socket, in the INT position. Then place the card back into slot J31. Under normal operation, it is possible to leave the ROM chip in the CPU card at all times. When this is done, maintenance can be performed by simply placing the switch in the INT position. To return to normal operation, place the switch in the EXT position and reset unit. Power-up the control unit. Testing may be performed by placing certain stream select switches in the active (up) position. Table A-1 shows the types of tests, and the following paragraphs describe them.

LED Testing.—The testing of LED's 1 through 6 can be done by placing the desired stream select switch in the active (up) position. The green LED above the select switch should come on, indicating the switch is in the active position. A corresponding red LED located next to the plugging factor display should also come on, and should latch and remain on until another LED is selected.

Printer Test.—The printer may be tested by placing stream select switches 1 and 2 in the active (up) position. The printer should then print out the entire ASCII character set. Returning the switches to their inactive positions should stop the printer.

Alarms Test.—Testing the alarms may be accomplished by placing stream select switches 1 and 3 in the active (up) position. Also, place the audible alarm switch in the ON position. By first pushing then releasing the alarm reset pushbutton, the alarms should clear for about 2 seconds before actuating again. To stop the test, place the stream select and audible alarm switches in the OFF or inactive (down) position and push alarm reset.

Plugging Factor Display Test.—The displays for the plugging factor may be tested by placing stream select switches 2 and 3 in the active (up) position. Each of the six stream displays, starting with stream 6, should display the numbers zero through nine. When the display routine for stream 1 is complete, the sequence should repeat. To stop the test, place the stream select switches in the inactive (down) position. The routine should complete the sequence and then stop.

Thumbdials Test.—To test the thumbdials, place stream select switches 1, 2, and 3 in the active (up) position. Each position selected on the thumbdial should be reflected in one of the displays used for the plugging factor. To stop the test, place the stream select switches in the inactive (down) position.

Clock Test.—The clock test can be performed by placing stream select switches 1 and 4 in the active (up) position. The displays for the plugging factors should reflect the clock display. The plugging factor display for stream 1 should contain the Julian day indicated on the clock, the display for stream 2 should contain the hour, and the display for stream 3 should contain the minutes. To stop the test, place the stream select switches in the inactive (down) position.

SSR Test.—To test the relays, select the appropriate switches corresponding to the desired relay to be tested according to table A-1. After the switches have been placed in the active (up) position, the relay may be tested by first pushing and then releasing the alarm reset pushbutton. Pushing the pushbutton activates the relay, and

Table A-1.—*Control unit tests*

Test	Stream Select Switches						Remarks
	1	2	3	4	5	6	
LED 1	X						
LED 2		X					
LED 3			X				
LED 4				X			
LED 5					X		
LED 6						X	
Printer	X	X					
Alarms	X		X				
Displays		X	X				
Thumbdials	X	X	X				
Clock	X			X			
Relay 1	X	X			X		Solenoid for stream 1
Relay 2			X		X		Solenoid for stream 2
Relay 3	X		X		X		Solenoid for stream 3
Relay 4		X	X		X		Solenoid for stream 4
Relay 5	X	X	X		X		Solenoid for stream 5
Relay 6				X	X		Solenoid for stream 6
Relay 7	X			X	X		Solenoid for supply head
Relay 8		X		X	X		Solenoid for fill tank drain
Relay 9	X	X		X	X		Solenoid for pressure head
Relay 10			X	X	X		Tape advance motor
Relay 11	X		X	X	X		
Relay 12		X	X	X	X		
Relay 13	X	X	X	X	X		
Relay 14	X					X	
A/D Test		X		X			
D/A 1 test			X	X			
D/A 2 test	X		X	X			
D/A 3 test		X	X	X			
D/A 4 test	X	X	X	X			
D/A 5 test	X				X		
D/A 6 test		X			X		
Sensor Test	X	X		X			
Stream Latch							

X indicates switch in active (up) position

releasing deactivates the relay. To stop the test, place all stream select switches in the inactive (down) position.

A/D Testing.—Power-down the control unit. Connect an ammeter capable of reading 20 mA or more between "Stream 1" (+) located on rear panel of control unit TB5 and "Pressure In" (+) located on rear panel of control unit TB6. Also, connect "Stream 1" (−) to "Pressure In" (−). Power-up the control unit and proceed with testing.

First, place stream select switches 2 and 4 in the active (up) position. Set the cycle time thumbdial to zero. Plugging factor displays 1 and 2 should read zero, and the ammeter should be reading 4 mA ± 1 percent. Set the cycle time thumbdial to 99. Plugging factor display 1 should read 99, plugging factor display 2 should read 377 (disregard the decimal point), and the ammeter should read 20 mA ± 1 percent. Testing is now completed. Place the cycle time thumbdial to zero, place stream select switches 2 and 4 to the inactive (down) position, power-down the control unit, and disconnect the connections made on the rear panel of the control unit.

D/A Testing.—Power-down the control unit. Disconnect the wire connected to the plus (+) terminal of the stream to be tested on rear panel of control unit TB5. Connect the minus (−) lead of an ammeter capable of reading 20 mA or more to the wire that was disconnected, and connect the plus (+) lead of the ammeter to the plus (+) terminal of the stream to be tested. Power-up the control unit. Place stream select switches for the desired stream in the active (up) position. Set the cycle time thumbdial to zero. The plugging factor display for the stream being tested should read zero, and the ammeter should read 4 mA ± 1 percent. Set the cycle time thumbdial to 9.9. The plugging factor display for the stream being tested should read 99 and the ammeter should read 20 mA ± 1 percent. Set the cycle time thumbdial to zero, place the stream select switches in the inactive (down) position, and power-down the control unit. Disconnect the ammeter, and reconnect the wire that was removed from the plus (+) terminal of the stream tested. Repeat this procedure until all streams have been tested.

Sensor Test.—Power-up control unit. Place stream select switches 1, 2, and 4 in the active (up) position. Short together the ground probe and the high-level probe located in the sample fill tank of the tester unit. The red LED next to plugging factor display No. 1 on the front panel of the control unit should come on for about 0.5 second and then go out. Disconnecting and reconnecting the short should again cause the red LED to come on for 0.5 second. Short together the ground probe and the low level probe. The LED will again come on for 0.5 second and go out. Remove the short from the probes.

Millipore Tape Sensor Test.—With stream select switches 1, 2, and 4 in the active (up) position, the tape spool may be rotated to allow the spool blades to pass through the sensor detector. As the blades pass through the detector, the LED next to the plugging factor display No. 2 should blink off and then on. When the test is completed, place the stream select switches in the inactive (down) position.

Stream Latch Test.—The stream latch test may be performed by first placing the battery backup switch, located on the front panel of the control unit, in the ON position. Then, place one of the stream select switches in the active (up) position. The stream selected should now be indicated on the red LED located next to the plugging factor display for that stream. After the red LED comes on, place the same stream select switch in the inactive (down) position. Power-down, and then power-up the control unit. The same red LED, which indicated the stream selected, should reappear and processing should continue in the normal manner.

Printer Message Testing

Power-down the control unit. The printer testing may be accomplished by inserting the ROM chip labeled PFM W/PRINT into the CPU No. 1 board located in the rear of the control unit slot J31. Remove the board from this slot. After inserting the ROM chip into the ejection type socket, place the toggle switch, located next to the ejection socket, in the INT position. Place the card back into slot J31. Power-up the control unit. The printer may now be tested by placing stream select switch 1 into the active (up) position. The printer should now print out a plugging factor system message. Placing the stream select switch in the inactive (down) position will stop printer operation. Placing each stream select switch in the active (up) position should cause different system messages to be printed. Table A-2 shows the printer message corresponding to the six stream select switches. Power-down the control unit to remove the ROM chip from the CPU No. 1 board in slot J31. Replace the board originally in slot J31. Also, place the toggle switch on the card in the EXT position. The system should now be ready for normal operation.

Table A-2.—*Printer test messages*

Printer message	Stream select switch					
	1	2	3	4	5	6
Plugging factor alarm					X	
T1 alarm		X				
T2 alarm				X		
Pressure alarm	X					
Start of cycle						X
Normal			X			

X indicates switch in active (up) position

Miscellaneous Maintenance

Pressure Transducer Switch.—A toggle switch labeled PRESS for the pressure transducer is located on I/O card No. 1 in slot J41 in the rear of the control unit. With the switch in the active (up) position, the pressure transducer input is enabled; with the switch in the inactive (down) position, the transducer input is disabled.

Printer Switch.—A switch for the printer is located on I/O card No. 1 in slot J41 in the rear of the control unit. This switch must be in the active (up) position for printer operation.

Calendar Switch.—The calendar switch for selecting 365 (up position) or 366 (down position) calendar days is located on the clock driver card in slot J61 in the rear of the control unit. Placing the toggle switch on the card in the 366 position allows selection during leap years. Power-down the control unit to remove the maintenance ROM and place the system ROM back into the CPU No. 1 board in slot J31. Also, place the toggle switch on the card in the EXT position. The system should now be ready for normal operation.

APPENDIX B

CALIBRATION PROCEDURES

APPENDIX B
CALIBRATION PROCEDURES

Pressure Input Board

To calibrate this board, the "A/D Testing" procedure covered in appendix A must be used.

Once this A/D test is running, the calibration can be performed. First, calibrate the A/D by performing the following steps:

1. Place the switch on the pressure input card edge in the calibrate (CAL) position.

2. Connect a voltage source to the CAL IN test point. This test point is directly above the switch. The ground test point, labeled GND, is directly above the CAL IN test point.

3. Apply zero volts and adjust the OV pot to obtain zero on the display for stream 2. Since only the most significant eight bits of the A/D are used and these trim adjustments are over a small range, it may be difficult to cause the reading to be out of calibration.

4. Apply 10 volts and adjust the 10V pot to obtain 377 on the display.

Next, calibrate the signal conditioning input by connecting a current source to the terminals on the back panel. The current output from stream 1 may be used, see testing procedure in appendix A. Then, follow the steps:

1. Set current source to 4 mA.

2. Place switch on card edge in RUN position.

3. Measure voltage at test point TP. Adjust ZERO ADJ pot for zero volts. Also, zero should be on the stream 2 display.

4. Set current source to 20 mA.

5. Adjust GAIN ADJ pot to read 10 volts at test point TP and 377 on display.

6. Repeat steps 1 through 5 until no further adjustments are required.

Current Output Board

To calibrate this board, the following steps are required:

1. Place the 12 DIP switches in the CAL position.

2. Place the switch on the current output board edge in the "Zero" position.

3. Adjust the ZERO ADJ pot to obtain zero volts at test point TP.

4. Measure current at associated output terminals and adjust the 4-mA pot to obtain 4 mA at the output.

5. Place the switch on the current output board edge in the "Full Scale" position.

6. Adjust the GAIN ADJ pot to obtain 10 volts at test point TP.

7. Adjust the 20-mA pot to obtain 20 mA of current at the output terminals.

8. Repeat steps 1 through 7 until no further adjustments are required.

APPENDIX C

PFMEC SYSTEM LISTINGS

```
*
**********
*
*
*       PLUGGING FACTOR MONITOR
*
*
**********
**********
**********
*
*       POWER-UP VECTOR
*
                                  ORG 0B
        000000  RESET             NOP
000001  000004                    JMP INITIAL
000002  000034
*
*       EXTERNAL INTERRUPT VECTOR
*
000003  000000  EXTINT            NOP
000004  000000                    NOP
000005  000004                    JMP *
000006  000005
*
*       TIMER/COUNTER INTERRUPT VECTOR
*
* INCREMENT A TIMER IN REGISTERS 2,3, &4
* (BANK 0).  INCREMENTS BCD COUNT BY 20
* MSEC FOR EACH TIMER/COUNTER INTERRUPT.
000007  000065  T/CINT            DITC
000010  000305                    SR0
000011  000251                    STA 1
000012  000227                    CLC
000013  000043                    LDAN 2
000014  000002
000015  000152                    ADD 2
000016  000127                    DAA
000017  000252                    STA 2
000020  000346                    BCC RETURN
000021  000031
000022  000047                    CLA
000023  000173                    ADC 3
000024  000127                    DAA
000025  000253                    STA 3
000026  000346                    BCC RETURN
000027  000031
000030  000034                    INC 4
000031  000371  RETURN            LDA 1
000032  000045                    ENTC
000033  000223                    RETR
```

```
0047  *
0048  *        INITIALIZATION
0049  *
0050  000034  000043  INITIAL  LDAN H10H
      000035  000020
0051  000036  000072           OUT 2
0052  000037  000074           OUTX 4
0053  000040  000075           OUTX 5
0054  000041  000043           LDAN 1
      000042  000001
0055  000043  000076           OUTX 6
0056  000044  000047           CLA
0057  000045  000043           LDAN H20H
      000046  000040
0058  000047  000072           OUT 2
0059  000050  000075           OUTX 5
0060  000051  000076           OUTX 6
0061  000052  000077           OUTX 7
0062  000053  000027           INA
0063  000054  000074           OUTX 4
0064  000055  000043           LDAN H30H
      000056  000060
0065  000057  000072           OUT 2
0066  000060  000074           OUTX 4
0067  000061  000043           LDAN H40H
      000062  000100
0068  000063  000072           OUT 2
0069  000064  000074           OUTX 4
0070  000065  000075           OUTX 5
0071  000066  000076           OUTX 6
0072  000067  000043           LDAN H50H
      000070  000120
0073  000071  000072           OUT 2
0074  000072  000074           OUTX 4
0075  000073  000076           OUTX 6
0076  000074  000277           MOVN H05H,7
      000075  000005
0077  000076  000064           CALL DELAY
      000077  0003[illegible]4
0078  000100  0000[illegible]           IN 1
0079  000101  000107           SWAP
0080  000102  000067           CMA
0081  000103  000123           ANDN 7
      000104  000007
0082  000105  000255           STA 5
0083  *
0084  *        START OF PROGRAM
0085  *
0086  000106  000375  START    LDA 5
0087  000107  000067           CMA
0088  000110  000003           ADDN 7
```

```
     000111  000007
0089 000112  000067            CMA
0090 000113  000362            BBS OVER1,7
     000114  000117
0091 000115  000275            MOVN 0,5
     000116  000000
0092 000117  000375  OVER1     LDA 5
0093 000120  000226            BNZ OVER2
     000121  000123
0094 000122  000035            INC 5
0095 000123  000375  OVER2     LDA 5
0096 000124  000103            IORN H0F0H
     000125  000360
0097 000126  000071            OUT 1
0098 000127  000043            LDAN H58H
     000130  000130
0099 000131  000072            OUT 2
0100 000132  000076            OUTX 6
0101 000133  000047            CLA
0102 000134  000076            OUTX 6
0103 000135  000375            LDA 5
0104 000136  000323            XORN 5
     000137  000005
0105 000140  000306            BZ FIVE
     000141  000165
0106 000142  000375            LDA 5
0107 000143  000323            XORN 6
     000144  000006
0108 000145  000306            BZ SIX
     000146  000175
0109 000147  000375            LDA 5
0110 000150  000256            STA 6
0111 000151  000043            LDAN H30H
     000152  000060
0112 000153  000072            OUT 2
0113 000154  000017            INX 7
0114 000155  000147  LOOP2     RRC
0115 000156  000356            DBNZ LOOP2,6
     000157  000155
0116 000160  000366            BCS ACTIVE
     000161  000205
0117 000162  000035  INACTIVE  INC 5
0118 000163  000004            JMP START
     000164  000106
0119 000165  000043  FIVE      LDAN H40H
     000166  000100
0120 000167  000072            OUT 2
0121 000170  000017            INX 7
0122 000171  000022            BBS ACTIVE,0
     000172  000205
0123 000173  000004            JMP INACTIVE
```

```
       000174  000162
0124   000175  000043  SIX      LDAN H40H
       000176  000100
0125   000177  000072           OUT 2
0126   000200  000017           INX 7
0127   000201  000052           BBS ACTIVE,1
       000202  000205
0128   000203  000004           JMP INACTIVE
       000204  000162
0129   000205  000043  ACTIVE   LDAN H20H
       000206  000040
0130   000207  000072           OUT 2
0131   000210  000375           LDA 5
0132   000211  000227           CLC
0133   000212  000367           RLC
0134   000213  000076           OUTX 6
0135   000214  000043  ADVANCE  LDAN H48H
       000215  000110
0136   000216  000072           OUT 2
0137   000217  000076           OUTX 6
0138   *
0139   *       NEW PAPER FAULT DETECTION
0140   *
0141   000220  000047           CLA             START TIMER
0142   000221  000252           STA 2
0143   000222  000253           STA 3
0144   000223  000254           STA 4
0145   000224  000142           STAT
0146   000225  000125           TIME
0147   000226  000045           ENTC
0148   000227  000043           LDAN H10H       CHECK OPTIC INPUT
       000230  000020
0149   000231  000072           OUT 2
0150   000232  000017           INX 7
0151   000233  000062           BBS ADV1,1
       000234  000271
0152   000235  000017  ADV2     INX 7
0153   000236  000052           BBS ANEXT,1
       000237  000306
0154   000240  000373           LDA 3           CHECK TIMER
0155   000241  000323           XORN 4
       000242  000004
0156   000243  000226           BNZ ADV2
       000244  000235
0157   000245  000065  ALARM    DITC            STOP MOTOR
0158   000246  000145           STOP
0159   000247  000043           LDAN H40H
       000250  000100
0160   000251  000072           OUT 2
0161   000252  000076           OUTX 6
0162   000253  000043           LDAN H25H       SET ALARM
```

```
     000254  000045
0163 000255  000072            OUT 2
0164 000256  000077            OUTX 7
0165 000257  000047            CLA
0166 000260  000077            OUTX 7
0167 000261  000043            LDAN H40H       WAIT FOR ALARM RESET
     000262  000100
0168 000263  000072            OUT 2
0169 000264  000017            INX 7
0170 000265  000122            BBS *-1,2
     000266  000264
0171 000267  000004            JMP ADVANCE
     000270  000214
0172 000271  000017  ADV1      INX 7           CHECK OPTIC INPUT
0173 000272  000067            CMA
0174 000273  000062            BBS ANEXT,1
     000274  000306
0175 000275  000373  ADV3      LDA 3           CHECK TIMER
0176 000276  000323            XORN 4
     000277  000004
0177 000300  000226            BNZ ADV1
     000301  000271
0178 000302  000004            JMP ALARM
     000303  000245
0179 000304  000044  GOOD1LK   JMP GOOD1
     000305  000024
0180 000306  000373  ANEXT     LDA 3
0181 000307  000323            XORN 3
     000310  000003
0182 000311  000226            BNZ ANEXT
     000312  000306
0183 000313  000065            DITC            STOP MOTOR
0184 000314  000145            STOP
0185 000315  000043            LDAN H40H
     000316  000100
0186 000317  000072            OUT 2
0187 000320  000076            OUTX 6
0188 000321  000276            MOVN 6,6
     000322  000006
0189 000323  000164            CALL PRINT
     000324  000163
0190 000325  000064  OKAY      CALL VALVEON
     000326  000332
0191 000327  000277            MOVN H10H,7
     000330  000020
0192 000331  000064            CALL DELAY
     000332  000314
0193 000333  000043            LDAN H21H       "LOWER HEAD"
     000334  000041
0194 000335  000072            OUT 2
0195 000336  000216            IORX 6
```

```
0196  000337  000277           MOVN 3,7
      000340  000003
0197  000341  000064           CALL DELAY
      000342  000314
0198  000343  000043           LDAN 4
      000344  000004
0199  000345  000215           IORX 5
0200  000346  000277           MOVN 5,7
      000347  000005
0201  000350  000064           CALL DELAY
      000351  000314
0202  000352  000043           LDAN 8
      000353  000010
0203  000354  000215           IORX 5
0204  000355  000276           MOVN H0FFH,6
      000356  000377
0205  000357  000270           MOVN H20H,0
      000360  000040
0206  000361  000124           CALL TIMEOUT
      000362  000122
0207  000363  000166           BF1 GOOD1LK
      000364  000304
0208  000365  000276  PRESSURE MOVN 1,6
      000366  000001
0209  000367  000164           CALL PRINT
      000370  000163
0210  000371  000043  NOPRINT1 LDAN H22H
      000372  000042
0211  000373  000072           OUT 2
0212  000374  000077           OUTX 7
0213  000375  000047           CLA
0214  000376  000077           OUTX 7
0215  000377  000124  INSERT   CALL SONALERT
      000400  000032
0216  000401  000325           SR1
0217  000402  000270           MOVN 9,0
      000403  000011
0218  000404  000271           MOVN H99H,1
      000405  000231
0219  000406  000305           SR0
0220  000407  000064           CALL LATCH12
      000410  000367
0221  000411  000124           CALL CLOSEDWN
      000412  000041
0222  000413  000035           INC 5
0223  000414  000004           JMP START
      000415  000106
0224  000416  000044  GOONLNK  JMP GOON
      000417  000053
0225  000420  000004  PRESSLK  JMP PRESSURE
      000421  000365
```

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```
0226  000422  000044  NOPRNTLK JMP NOPRINT2
      000423  000042
0227  000424  000277  GOOD1    MOVN 1,7
      000425  000001
0228  000426  000124           CALL THUMDIAL
      000427  000072
0229  000430  000124           CALL TIMEOUT
      000431  000122
0230  000432  000266           BF0 PRESSLK
      000433  000020
0231  000434  000166           BF1 GOONLNK
      000435  000016
0232  000436  000276           MOVN 2,6
      000437  000002
0233  000440  000164           CALL PRINT
      000441  000163
0234  000442  000043  NOPRINT2 LDAN H12H
      000443  000022
0235  000444  000072           OUT 2
0236  000445  000216           IORX 6
0237  000446  000043           LDAN 15B
      000447  000015
0238  000450  000236           ANDX 6
0239  000451  000004           JMP INSERT
      000452  000377
0240  000453  000043  GOON     LDAN H27H
      000454  000047
0241  000455  000072           OUT 2
0242  000456  000235           ANDX 5
0243  000457  000270           MOVN T1,0
      000460  000032
0244  000461  000124           CALL STORE
      000462  000061
0245  000463  000043           LDAN H54H
      000464  000124
0246  000465  000072           OUT 2
0247  000466  000074           OUTX 4
0248  000467  000015           INX 5
0249  000470  000103           IORN H0F0H
      000471  000360
0250  000472  000067           CMA
0251  000473  000250           STA 0
0252  000474  000043           LDAN 5
      000475  000005
0253  000476  000074           OUTX 4
0254  000477  000015           INX 5
0255  000500  000103           IORN H0F0H
      000501  000360
0256  000502  000067           CMA
0257  000503  000256           STA 6
0258  000504  000036           INC 6
```

```
0259  000505  000370            LDA 0
0260  000506  000226            BNZ OP2
      000507  000113
0261  000510  000316            DEC 6
0262  000511  000270  OP1       MOVN H0AH,0
      000512  000012
0263  000513  000277  OP2       MOVN H60H,7
      000514  000140
0264  000515  000264            CALL DELAY
      000516  000314
0265  000517  000350            DBNZ OP2,0
      000520  000113
0266  000521  000356            DBNZ OP1,6
      000522  000111
0267  000523  000043            LDAN H28H
      000524  000050
0268  000525  000072            OUT 2
0269  000526  000215            IORX 5
0270  000527  000276            MOVN H0FFH,6
      000530  000377
0271  000531  000270            MOVN H20H,0
      000532  000040
0272  000533  000124            CALL TIMEOUT
      000534  000122
0273  000535  000166            BF1 GOOD2
      000536  000141
0274  000537  000004  PRESLNK   JMP PRESSURE
      000540  000365
0275  000541  000277  GOOD2     MOVN 6,7
      000542  000006
0276  000543  000124            CALL THUMDIAL
      000544  000072
0277  000545  000124            CALL TIMEOUT
      000546  000122
0278  000547  000276            MOVN 0,6
      000550  000000
0279  000551  000266            BF0 PRESLNK
      000552  000137
0280  000553  000166            BF1 GOONA
      000554  000170
0281  000555  000124            CALL SONALERT
      000556  000032
0282  000557  000043            LDAN H14H
      000560  000024
0283  000561  000072            OUT 2
0284  000562  000216            IORX 6
0285  000563  000043            LDAN 13B
      000564  000013
0286  000565  000236            ANDX 6
0287  000566  000276            MOVN 4,6
      000567  000004
```

```
0288  000570  000270  GOONA   MOVN TR,0
      000571  000035
0289  000572  000124          CALL STORE
      000573  000061
0290  000574  000124          CALL CLOSEDWN
      000575  000041
0291  000576  000124          CALL P.F.CALC
      000577  000253
0292  000600  000305          SR0
0293  000601  000043          LDAN H59H
      000602  000131
0294  000603  000072          OUT 2
0295  000604  000074          OUTX 4
0296  000605  000015          INX 5
0297  000606  000257          STA 7
0298  000607  000043          LDAN H0AH
      000610  000012
0299  000611  000074          OUTX 4
0300  000612  000015          INX 5
0301  000613  000107          SWAP
0302  000614  000117          IOR 7
0303  000615  000067          CMA
0304  000616  000257          STA 7
0305  000617  000270          MOVN PF,0
      000620  000030
0306  000621  000360          LDAI 0
0307  000622  000107          SWAP
0308  000623  000123          ANDN H0F0H
      000624  000360
0309  000625  000251          STA 1
0310  000626  000030          INC 0
0311  000627  000360          LDAI 0
0312  000630  000107          SWAP
0313  000631  000123          ANDN H0FH
      000632  000017
0314  000633  000111          IOR 1
0315  000634  000251          STA 1
0316  000635  000270          MOVN 8,0
      000636  000010
0317  000637  000377  LOOP4   LDA 7
0318  000640  000367          RLC
0319  000641  000257          STA 7
0320  000642  000366          BCS SET
      000643  000253
0321  000644  000371          LDA 1
0322  000645  000367          RLC
0323  000646  000251          STA 1
0324  000647  000366          BCS ALARMS
      000650  000262
0325  000651  000044          JMP ENDLOOP
      000652  000260
```

```
0326  000653  000371  SET       LDA 1
0327  000654  000367            RLC
0328  000655  000251            STA 1
0329  000656  000346            BCC CLEAR
      000657  000300
0330  000660  000350  ENDLOOP   DBNZ LOOP4,0
      000661  000237
0331  000662  000124  ALARMS    CALL SONALERT
      000663  000032
0332  000664  000043            LDAN H18H
      000665  000030
0333  000666  000072            OUT 2
0334  000667  000216            IORX 6
0335  000670  000043            LDAN 7
      000671  000007
0336  000672  000236            ANDX 6
0337  000673  000376            LDA 6
0338  000674  000122            BBS CLEAR,2
      000675  000300
0339  000676  000276            MOVN 5,6
      000677  000005
0340  000700  000064  CLEAR     CALL LATCH12
      000701  000367
0341  000702  000376            LDA 6
0342  000703  000226            BNZ TOOLATE
      000704  000307
0343  000705  000276            MOVN 3,6
      000706  000003
0344  000707  000164  TOOLATE   CALL PRINT
      000710  000163
0345  000711  000035  NOPRINT3  INC 5
0346  000712  000004            JMP START
      000713  000106
0347  *
0348  *               SUBROUTINE DELAY
0349  *
0350  * DELAYS FOR BCD COUNT (IN SECONDS)
0351  * PASSED IN R7
0352  000714  000047  DELAY     CLA
0353  000715  000252            STA 2
0354  000716  000253            STA 3
0355  000717  000254            STA 4
0356  000720  000142            STAT
0357  000721  000125            TIME
0358  000722  000045            ENTC
0359  000723  000373  LOOP0     LDA 3
0360  000724  000337            XOR 7
0361  000725  000226            BNZ LOOP0
      000726  000323
0362  000727  000065            DITC
0363  000730  000145            STOP
```

```
0364  000731  000223             RETR
0365  *
0366  *       SUBROUTINE VALVE ON
0367  *
0368  * TURNS ON APPROPRIATE STREAM INLET
0369  * VALVE DEPENDING ON STREAM COUNT IN
0370  * REGISTER #5.
0371  000732  000043  VALVEON  LDAN H20H
      000733  000040
0372  000734  000072           OUT 2
0373  000735  000227           CLC
0374  000736  000247           CMC
0375  000737  000375           LDA 5
0376  000740  000256           STA 6
0377  000741  000047           CLA
0378  000742  000367  LOOP1    RLC
0379  000743  000356           DBNZ LOOP1,6
      000744  000342
0380  000745  000214           IORX 4
0381  000746  000107           SWAP
0382  000747  000215           IORX 5
0383  000750  000107           SWAP
0384  000751  000234           ANDX 4
0385  000752  000107           SWAP
0386  000753  000235           ANDX 5
0387  000754  000223  R2D2     RETR
0388  *
0389  *       SUBROUTINE STROBE
0390  *
0391  * STROBES IN 12-BIT CMOS DATA LATCH.
0392  * USED BY SUBROUTINE "12-BIT LATCH".
0393  000755  000043  STROBE   LDAN H28H
      000756  000050
0394  000757  000072           OUT 2
0395  000760  000077           OUTX 7
0396  000761  000047           CLA
0397  000762  000077           OUTX 7
0398  000763  000043           LDAN H40H
      000764  000100
0399  000765  000072           OUT 2
0400  000766  000223           RETR
0401  *
0402  *       SUBROUTINE 12-BIT LATCH
0403  *
0404  * OUTPUTS PLUG FACTOR TO 12-BIT CMOS
0405  * LTCH (I.E. LED DISPLAYS & CURRENT
0406  * NUTPUTS).  DATA IN RAM LOCATIONS
0407  * 24 & 25.
0408  000767  000043  LATCH12  LDAN H40H
      000770  000100
0409  000771  000072           OUT 2
```

```
0410  000772  000375           LDA 5
0411  000773  000075           OUTX 5
0412  000774  000270           MOVN FF,0
      000775  000030
0413  000776  000360           LDAI 0
0414  000777  000074           OUTX 4
0415  001000  000043           LDAN 4
      001001  000004
0416  001002  000076           OUTX 6
0417  001003  000064           CALL STROBE
      001004  000355
0418  001005  000030           INC 0
0419  001006  000360           LDAI 0
0420  001007  000107           SWAP
0421  001010  000074           OUTX 4
0422  001011  000043           LDAN 2
      001012  000002
0423  001013  000076           OUTX 6
0424  001014  000064           CALL STROBE
      001015  000355
0425  001016  000360           LDAI 0
0426  001017  000074           OUTX 4
0427  001020  000043           LDAN 1
      001021  000001
0428  001022  000076           OUTX 6
0429  001023  000064           CALL STROBE
      001024  000355
0430  001025  000047           CLA
0431  001026  000074           OUTX 4
0432  001027  000075           OUTX 5
0433  001030  000076           OUTX 6
0434  001031  000223           RETR
0435  *
0436  *       SUBROUTINE SONALERT
0437  *
0438  * TURNS ON SONALERT AND ALARM RELAY
0439  *
0440  001032  000043  SONALERT LDAN 24H
      001033  000044
0441  001034  000072           OUT 2
0442  001035  000077           OUTX 7
0443  001036  000047           CLA
0444  001037  000077           OUTX 7
0445  001040  000223           RETR
0446  *
0447  *       SUBROUTINE CLOSE DOWN
0448  *
0449  * OPENS FILTRATE TANK DRAIN VALVE,
0450  * BYPASS VALVE, AND MOVES FILTER
0451  * HEAD UP.  DELAYS FOR 3 SECONDS.
0452  * SHUTS OFF ALL STREAM INLET VALVES.
```

```
0453  001041  000043  CLOSEDWN LDAN H23H
      001042  000043
0454  001043  000072           OUT 2
0455  001044  000235           ANDX 5
0456  001045  000277           MOVN H10H,7
      001046  000020
0457  001047  000064           CALL DELAY
      001050  000314
0458  001051  000043           LDAN H0EH
      001052  000016
0459  001053  000236           ANDX 6
0460  001054  000277           MOVN 1,7
      001055  000001
0461  001056  000064           CALL DELAY
      001057  000314
0462  001060  000203           RET
0463  *
0464  *          SUBROUTINE STORE
0465  *
0466  * TRANSFERS TIME COUNT (IN SECONDS)
0467  * TO T1 OR T2.  IF ARGUMENT IN R0
0468  * IS "1A", THEN T1      IF "1D", THEN T2.
0469  001061  000374  STORE    LDA 4
0470  001062  000240           STAI 0
0471  001063  000030           INC 0
0472  001064  000373           LDA 3
0473  001065  000240           STAI 0
0474  001066  000030           INC 0
0475  001067  000372           LDA 2
0476  001070  000240           STAI 0
0477  001071  000223           RETR
0478  *
0479  *          SUBROUTINE THUMDIAL
0480  *
0481  001072  000043  THUMDIAL LDAN H50H
      001073  000120
0482  001074  000072           OUT 2
0483  001075  000377           LDA 7
0484  001076  000074           OUTX 4
0485  001077  000015           INX 5
0486  001100  000250           STA 0
0487  001101  000037           INC 7
0488  001102  000377           LDA 7
0489  001103  000074           OUTX 4
0490  001104  000015           INX 5
0491  001105  000107           SWAP
0492  001106  000110           IOR 0
0493  001107  000067           CMA
0494  001110  000250           STA 0
0495  001111  000037           INC 7
0496  001112  000377           LDA 7
```

```
0497  001113  000074              OUTX 4
0498  001114  000015              INX 5
0499  001115  000067              CMA
0500  001116  000123              ANDN H0FH
      001117  000017
0501  001120  000256              STA 6
0502  001121  000223              RETR
0503  *
0504  *       SUBROUTINE TIMEOUT
0505  *
0506  001122  000245    TIMEOUT   CLF1
0507  001123  000043              LDAN H0FFH
      001124  000377
0508  001125  000336              XOR 6
0509  001126  000226              BNZ HOP1
      001127  000131
0510  001130  000265              CMF1
0511  001131  000166    HOP1      BF1 HOP2
      001132  000137
0512  001133  000277              MOVN 1,7
      001134  000001
0513  001135  000064              CALL DELAY
      001136  000314
0514  001137  000047    HOP2      CLA
0515  001140  000252              STA 2
0516  001141  000253              STA 3
0517  001142  000254              STA 4
0518  001143  000142              STAT
0519  001144  000125              TIME
0520  001145  000045              ENTC
0521  001146  000206    LOOPY     BIL MATER
      001147  000236
0522  001150  000166              BF1 SKIPY
      001151  000220
0523  001152  000043              LDAN H10H
      001153  000020
0524  001154  000072              OUT 2
0525  001155  000017              INX 7
0526  001156  000162              BBS SKIPY,3
      001157  000220
0527  001160  000043              LDAN 8
      001161  000010
0528  001162  000075              OUTX 5
0529  001163  000047              CLA
0530  001164  000075              OUTX 5
0531  001165  000043              LDAN H40H
      001166  000100
0532  001167  000072              OUT 2
0533  001170  000017    AGAIN     INX 7
0534  001171  000162              BBS AGAIN,3
      001172  000170
```

```
001173  000043            LDAN H30H
001174  000060
001175  000072            OUT 2
001176  000016            INX 6
001177  000067            CMA
001200  000123            ANDN H0FH
001201  000017
001202  000323            XORN 9
001203  000011
001204  000226            BNZ PROBLEM
001205  000214
001206  000015            INX 5
001207  000067            CMA
001210  000162            BBS SKIPY,3
001211  000220
001212  000122            BBS SKIPY,2
001213  000220
001214  000205  PROBLEM   CLF0
001215  000225            CMF0
001216  000104            JMP ENTER
001217  000240
001220  000205  SKIPY     CLF0
001221  000166            BF1 HOP3
001222  000227
001223  000374            LDA 4
001224  000336            XOR 6
001225  000226            BNZ LOOPY
001226  000146
001227  000373  HOP3      LDA 3
001230  000330            XOR 0
001231  000226            BNZ LOOPY
001232  000146
001233  000245            CLF1
001234  000104            JMP ENTER
001235  000240
001236  000245  WATER     CLF1
001237  000265            CMF1
001240  000065  ENTER     DITC
001241  000145            STOP
001242  000373            LDA 3
001243  000003            ADDN 1
001244  000001
001245  000127            DAA
001246  000253            STA 3
001247  000346            BCC HOP4
001250  000252
001251  000034            INC 4
001252  000203  HOP4      RET
*
*         SUBROUTINE P.F.CALC
*
```

```
0573  * CALCULATES THE PLUGGING FACTOR
0574  * BY PERFORMING:[100-(100*T1/T2))]
0575  001253  000325  P.F.CALC SR1                 IF T2<OR=T1, SET PF=00,
0576  001254  000227           CLC
0577  001255  000372           LDA 2
0578  001256  000067           CMA
0579  001257  000155           ADD 5
0580  001260  000067           CMA
0581  001261  000306           BZ .A
      001262  000267
0582  001263  000366           BCS .C
      001264  000301
0583  001265  000346           BCC .B
      001266  000275
0584  001267  000227  .A       CLC
0585  001270  000373           LDA 3
0586  001271  000067           CMA
0587  001272  000156           ADD 6
0588  001273  000366           BCS .C
      001274  000301
0589  001275  000047  .B       CLA
0590  001276  000250           STA 0
0591  001277  000251           STA 1
0592  001300  000203           RET
0593  001301  000047  .C       CLA                  INITIALIZE QUOTIENT
0594  001302  000250           STA 0
0595  001303  000251           STA 1
0596  001304  000305           SR0
0597  001305  000270           MOVN T1,0         SAVE T1
      001306  000032
0598  001307  000271           MOVN H20H,1
      001310  000040
0599  001311  000272           MOVN 3,2
      001312  000003
0600  001313  000164           CALL SAVE
      001314  000111
0601  001315  000274           MOVN 4,4          INITIALIZE DIGIT COUNTE
      001316  000004
0602  001317  000305  SUBTRACT SR0               SAVE PARTIAL DIVIDEND
0603  001320  000270           MOVN T1,0
      001321  000032
0604  001322  000271           MOVN H23H,1
      001323  000043
0605  001324  000272           MOVN 3,2
      001325  000003
0606  001326  000164           CALL SAVE
      001327  000111
0607  001330  000325           SR1                SUBTRACT T2 FROM T1
0608  001331  000374           LDA 4
0609  001332  000067           CMA
0610  001333  000157           ADD 7
```

```
001334  000164              CALL DAA
001335  000120
001336  000254              STA 4
001337  000373              LDA 3
001340  000067              CMA
001341  000176              ADC 6
001342  000164              CALL DAA
001343  000120
001344  000253              STA 3
001345  000372              LDA 2
001346  000067              CMA
001347  000175              ADC 5
001350  000164              CALL DAA
001351  000120
001352  000252              STA 2
001353  000000              NOP
001354  000000              NOP
001355  000000              NOP
001356  000000              NOP
001357  000000              NOP
001360  000366              BCS RESTORE   TEST FOR BORROW
001361  000365
001362  000031              INC 1         INCREMENT QUOTIENT
001363  000104              JMP SUBTRACT
001364  000317
001365  000305  RESTORE     SR0           RESTORE PARTIAL DIVIDEND
001366  000270              MOVN H23H,0
001367  000043
001370  000271              MOVN T1,1
001371  000032
001372  000272              MOVN 3,2
001373  000003
001374  000164              CALL SAVE
001375  000111
001376  000325  SHIFT       SR1           SHIFT THE PARTIAL DIVIDEND
001377  000372              LDA 2
001400  000123              ANDN H0FH
001401  000017
001402  000107              SWAP
001403  000252              STA 2
001404  000373              LDA 3
001405  000123              ANDN H0F0H
001406  000360
001407  000107              SWAP
001410  000112              IOR 2
001411  000252              STA 2
001412  000373              LDA 3
001413  000123              ANDN H0FH
001414  000017
001415  000107              SWAP
001416  000253              STA 3
```

```
0650  001417  000374            LDA 4
0651  001420  000123            ANDN H0F0H
      001421  000360
0652  001422  000107            SWAP
0653  001423  000113            IOR 3
0654  001424  000253            STA 3
0655  001425  000374            LDA 4
0656  001426  000123            ANDN H0FH
      001427  000017
0657  001430  000107            SWAP
0658  001431  000254            STA 4
0659  001432  000305            SR0             TEST FOR COMPLETION
0660  001433  000354            DBNZ SHFTQ,4
      001434  000037
0661  001435  000144            JMP SUB100
      001436  000062
0662  001437  000325  SHFTQ     SR1             SHIFT QUOTIENT LEFT
0663  001440  000370            LDA 0
0664  001441  000123            ANDN H0FH
      001442  000017
0665  001443  000107            SWAP
0666  001444  000250            STA 0
0667  001445  000371            LDA 1
0668  001446  000123            ANDN H0F0H
      001447  000360
0669  001450  000107            SWAP
0670  001451  000110            IOR 0
0671  001452  000250            STA 0
0672  001453  000371            LDA 1
0673  001454  000123            ANDN H0FH
      001455  000017
0674  001456  000107            SWAP
0675  001457  000251            STA 1
0676  001460  000104            JMP SUBTRACT
      001461  000317
0677  001462  000325  SUB100    SR1             SUBTRACT RESULT FROM 1
0678  001463  000043            LDAN H0FFH
      001464  000377
0679  001465  000151            ADD 1
0680  001466  000164            CALL DAA
      001467  000120
0681  001470  000251            STA 1
0682  001471  000043            LDAN H0EFH
      001472  000357
0683  001473  000170            ADC 0
0684  001474  000164            CALL DAA
      001475  000120
0685  001476  000250            STA 0
0686  001477  000305            SR0             RESTORE T1
0687  001500  000270            MOVN H20H,0
      001501  000040
```

```
0688  001502  000271              MOVN T1,1
      001503  000032
0689  001504  000272              MOVN 3,2
      001505  000003
0690  001506  000164              CALL SAVE
      001507  000111
0691  001510  000203              RET
0692  *
0693  *         SUBROUTINE SAVE
0694  *
0695  * R0= FROM ADDRESS
0696  * R1= TO ADDRESS
0697  * R2= # OF LOCATIONS SAVED
0698  001511  000360  SAVE        LDAI 0
0699  001512  000241              STAI 1
0700  001513  000030              INC 0
0701  001514  000031              INC 1
0702  001515  000352              DBNZ SAVE,2
      001516  000111
0703  001517  000203              RET
0704  *
0705  *         SUBROUTINE DAA
0706  *
0707  * PERFORMS A DECIMAL ADJUST AS PART
0708  * OF A BCD SUBTRACTION.
0709  001520  000245  DAA         CLF1              SAVE CARRY
0710  001521  000305              SR0
0711  001522  000252              STA 2
0712  001523  000307              LDAS
0713  001524  000346              BCC CNSET
      001525  000127
0714  001526  000265              CMF1
0715  001527  000322  CNSET       BBS ACSET,6
      001530  000133
0716  001531  000144              JMP CCHECK
      001532  000137
0717  001533  000372  ACSET       LDA 2             AC SET ADD 6
0718  001534  000003              ADDN 6
      001535  000006
0719  001536  000252              STA 2
0720  001537  000166  CCHECK      BF1 CSET
      001540  000143
0721  001541  000144              JMP RESTRC
      001542  000147
0722  001543  000372  CSET        LDA 2             CARRY SET ADD 60H
0723  001544  000003              ADDN H60H
      001545  000140
0724  001546  000252              STA 2
0725  001547  000372  RESTRC      LDA 2
0726  001550  000325              SR1
0727  001551  000227              CLC               RESTORE CARRY
```

```
0728  001552  000166                   BF1 SETC
      001553  000156
0729  001554  000144                   JMP OUT
      001555  000157
0730  001556  000247      SETC         CMC
0731  001557  000067      OUT          CMA                    COMPLEMENT RESULT
0732  001560  000203                   RET
0733  *
0734  *           SUBROUTINE PRINT
0735  *
0736  001561  000204      NOTLNK       JMP NOTNORM
      001562  000210
0737  001563  000204      PRINT        JMP PRINTL
      001564  000000
0738  002000                           ORG 2000B
0739  002000  000043      PRINTL       LDAN H10H
      002001  000020
0740  002002  000072                   OUT 2
0741  002003  000017                   INX 7
0742  002004  000122                   BBS PRN,2
      002005  000007
0743  002006  000203                   RET
0744  002007  000277      PRN          MOVN H05H,7
      002010  000005
0745  002011  000376                   LDA 6
0746  002012  000323                   XORN 6
      002013  000006
0747  002014  000226                   BNZ SKIPIOA
      002015  000024
0748  002016  000043      SKIPIO       LDAN H0DH
      002017  000015
0749  002020  000324                   CALL PRNT
      002021  000000
0750  002022  000357                   DBNZ SKIPIO,7
      002023  000016
0751  002024  000277      SKIPIOA      MOVN 12,7
      002025  000014
0752  002026  000273                   MOVN DATMSG-1,3
      002027  003061
0753  002030  000324                   CALL MEM
      002031  000052
0754  002032  000224                   CALL CALDAY
      002033  000363
0755  002034  000277                   MOVN 9,7
      002035  000011
0756  002036  000273                   MOVN TIMMSG-1,3
      002037  003075
0757  002040  000324                   CALL MEM
      002041  000052
0758  002042  000277                   MOVN 7,7
      002043  000007
```

```
0759 002044 000273           MOVN 3,3
     002045 000003
0760 002046 000224           CALL TIME
     002047 000343
0761 002050 000272           MOVN 2,2
     002051 000002
0762 002052 000043 TWICE     LDAN H3AH
     002053 000072
0763 002054 000324           CALL PRNT
     002055 000000
0764 002056 000273           MOVN 2,3
     002057 000002
0765 002060 000224           CALL TIME
     002061 000343
0766 002062 000352           DBNZ TWICE,2
     002063 000052
0767 002064 000277           MOVN 18,7
     002065 000022
0768 002066 000273           MOVN STRMSG-1,3
     002067 003107
0769 002070 000324           CALL MEM
     002071 000052
0770 002072 000375           LDA 5
0771 002073 000123           ANDN H0FH
     002074 000017
0772 002075 000003           ADDN H30H
     002076 000060
0773 002077 000324           CALL PRNT
     002100 000000
0774 002101 000277           MOVN 5,7
     002102 000005
0775 002103 000273           MOVN DBLCRMSG,3
     002104 003132
0776 002105 000324           CALL MEM
     002106 000052
0777 002107 000356           DBNZ NOTPRESS,6
     002110 000115
0778 002111 000273           MOVN PRESMESG-1,3
     002112 003137
0779 002113 000224           CALL ERR
     002114 000277
0780 002115 000356 NOTPRESS  DBNZ NOTT1,6
     002116 000123
0781 002117 000273           MOVN ASTT1MSG-1,3
     002120 003143
0782 002121 000224           CALL ERR
     002122 000277
0783 002123 000356 NOTT1     DBNZ NOTNORM,6
     002124 000210
0784 002125 000277 M3        MOVN 8,7
     002126 000010
```

```
0785  002127  000273           MOVN T1=MSG-1,3
      002130  003147
0786  002131  000324           CALL MEM
      002132  000052
0787  002133  000277           MOVN 3,7
      002134  000003
0788  002135  000272           MOVN 3,2
      002136  000003
0789  002137  000271           MOVN T1,1
      002140  000032
0790  002141  000224           CALL DM
      002142  000245
0791  002143  000277           MOVN 14,7
      002144  000016
0792  002145  000273           MOVN SECT2MSG-1,3
      002146  003157
0793  002147  000324           CALL MEM
      002150  000052
0794  002151  000277           MOVN 3,7
      002152  000003
0795  002153  000272           MOVN 3,2
      002154  000003
0796  002155  000271           MOVN T2,1
      002156  000035
0797  002157  000224           CALL DM
      002160  000245
0798  002161  000277           MOVN 21,7
      002162  000025
0799  002163  000273           MOVN SECPFMSG-1,3
      002164  003175
0800  002165  000324           CALL MEM
      002166  000052
0801  002167  000277           MOVN 2,7
      002170  000002
0802  002171  000272           MOVN 2,2
      002172  000002
0803  002173  000271           MOVN PF,1
      002174  000030
0804  002175  000224           CALL DM
      002176  000245
0805  002177  000277           MOVN 2,7
      002200  000002
0806  002201  000273           MOVN PRCNTMSG,3
      002202  003222
0807  002203  000324           CALL MEM
      002204  000052
0808  002205  000203  ABORT    RET
0809  002206  000204  STRCYCL  JMP STRCYC
      002207  000230
0810  002210  000356  NOTNORM  DBNZ NOTT2,6
      002211  000220
```

```
0811  002212  000273          MOVN ASTT2MSG-1,3
      002213  003224
0812  002214  000224          CALL ERR
      002215  000277
0813  002216  000204          JMP M3
      002217  000125
0814  002220  000356  NOTT2   DBNZ STRCYCL,6
      002221  000206
0815  002222  000273          MOVN ASTPFMSG-1,3
      002223  003230
0816  002224  000224          CALL ERR
      002225  000277
0817  002226  000204          JMP M3
      002227  000125
0818  002230  000356  STRCYC  DBNZ ABORT,6
      002231  000205
0819  002232  000277          MOVN 16,7
      002233  000020
0820  002234  000273          MOVN STRMSCG-1,3
      002235  003324
0821  002236  000324          CALL MEM
      002237  000052
0822  002240  000204          JMP ABORT
      002241  000205
0823  *
0824  *             SUBROUTINE DM
0825  *
0826  002242  000000          NOP
0827  002243  000000          NOP
0828  002244  000000          NOP
0829  002245  000361  DM      LDAI 1
0830  002246  000224          CALL SDM
      002247  000262
0831  002250  000031          INC 1
0832  002251  000357          DBNZ MSD,7
      002252  000254
0833  002253  000203          RET
0834  002254  000361  MSD     LDAI 1
0835  002255  000107          SWAP
0836  002256  000224          CALL SDM
      002257  000262
0837  002260  000204          JMP DM
      002261  000245
0838  *
0839  *             SUBROUTINE SDM
0840  *
0841  002262  000123  SDM     ANDN H0FH
      002263  000017
0842  002264  000003          ADDN H30H
      002265  000060
0843  002266  000324          CALL PRNT
```

```
      002267  000000
0844  002270  000352           DBNZ NOPERIOD,2
      002271  000276
0845  002272  000043           LDAN H2EH
      002273  000056
0846  002274  000324           CALL PRNT
      002275  000000
0847  002276  000203  NOPERIOD RET
0848  002277  000224  ERR      CALL ASTR
      002300  000326
0849  002301  000272           MOVN 5,2
      002302  000005
0850  002303  000043  ERRLOOP  LDAN H20H
      002304  000040
0851  002305  000324           CALL PRNT
      002306  000000
0852  002307  000352           DBNZ ERRLOOP,2
      002310  000303
0853  002311  000277           MOVN 4,7
      002312  000004
0854  002313  000324           CALL MEM
      002314  000052
0855  002315  000277           MOVN 7,7
      002316  000007
0856  002317  000273           MOVN ALARMMSG-1,3
      002320  003314
0857  002321  000324           CALL MEM
      002322  000052
0858  002323  000224           CALL ASTR
      002324  000326
0859  002325  000203           RET
0860  *
0861  *        SUBROUTINE ASTR
0862  *
0863  002326  000277  ASTR     MOVN H13H,7
      002327  000023
0864  002330  000043  CONTINUE LDAN H2AH
      002331  000052
0865  002332  000324           CALL PRNT
      002333  000000
0866  002334  000357           DBNZ CONTINUE,7
      002335  000330
0867  002336  000043           LDAN H0DH
      002337  000015
0868  002340  000324           CALL PRNT
      002341  000000
0869  002342  000203           RET
0870  *
0871  *        SUBROUTINE TIME
0872  *
0873  002343  000043  TIME     LDAN H50H
```

```
002344  000120
002345  000072           OUT 2
002346  000377           LDA 7
002347  000076           OUTX 6
002350  000017           INX 7
002351  000123           ANDN H0FH
002352  000017
002353  000003           ADDN H30H
002354  000060
002355  000324           CALL PRNT
002356  000000
002357  000317           DEC 7
002360  000353           DBNZ TIME,3
002361  000343
002362  000203           RET
*
*       ROUTINE TO PRINT CALENDAR DAY
*
*       R5 IS SAVED
*       R0= MONTH TABLE POINTER
*       R7= JULIAN DAY COUNTER
*       R5= DIGIT COUNTER
*
002363  000270  CALDAY   MOVN 27H,0    SAVE R5
002364  000047
002365  000375           LDA 5
002366  000240           STAI 0
002367  000030           INC 0
002370  000376           LDA 6
002371  000240           STAI 0
002372  000270           MOVN MONTBL-1,0 INITIALIZE
002373  002566
002374  000277           MOVN 1,7
002375  000001
002376  000043           LDAN 57H      READ 100'S DAYS
002377  000127
002400  000072           OUT 2
002401  000076           OUTX 6
002402  000017           INX 7
002403  000256           STA 6
002404  000036           INC 6
002405  000356  CL1      DBNZ CL2,6    CALCULATE MONTH/DAY
002406  000011
002407  000244           JMP CL3
002410  000026
002411  000227  CL2      CLC
002412  000307           LDAS
002413  000123           ANDN H3FH
002414  000077
002415  000327           STAS
002416  000275           MOVN 0,5
```

```
      002417  000000
0913  002420  000264  CL2A    CALL CNT
      002421  000203
0914  002422  000366          BCS CL1
      002423  000005
0915  002424  000346          BCC CL2A
      002425  000020
0916  002426  000043  CL3     LDAN 6         READ 10'S DAYS
      002427  000006
0917  002430  000076          OUTX 6
0918  002431  000017          INX 7
0919  002432  000256          STA 6
0920  002433  000036          INC 6
0921  002434  000356  CL4     DBNZ CL5,6     CALCULATE MONTH/DAY
      002435  000040
0922  002436  000244          JMP CL7
      002437  000051
0923  002440  000275  CL5     MOVN 0,5
      002441  000000
0924  002442  000264  CL6     CALL CNT
      002443  000203
0925  002444  000375          LDA 5
0926  002445  000222          BBS CL4,4
      002446  000034
0927  002447  000244          JMP CL6
      002450  000042
0928  002451  000043  CL7     LDAN 5         READ 1'S DAYS
      002452  000005
0929  002453  000076          OUTX 6
0930  002454  000017          INX 7
0931  002455  000256          STA 6
0932  002456  000036          INC 6
0933  002457  000356  CL8     DBNZ CL9,6     CALCULATE MONTH/DAY
      002460  000063
0934  002461  000244          JMP CL10
      002462  000071
0935  002463  000264  CL9     CALL CNT
      002464  000203
0936  002465  000244          JMP CL8
      002466  000057
0937  002467  000244  CNT1LK  JMP CNT1
      002470  000212
0938  002471  000377  CL10    LDA 7          CALCULATE DAY
0939  002472  000067          CMA
0940  002473  000027          INA
0941  002474  000257          STA 7
0942  002475  000370          LDA 0
0943  002476  000243          LDAA
0944  002477  000157          ADD 7
0945  002500  000257          STA 7
0946  002501  000307          LDAS
```

```
0947  002502  000123          ANDN H3FH
      002503  000077
0948  002504  000327          STAS
0949  002505  000377          LDA 7
0950  002506  000222          BBS CL11,4
      002507  000112
0951  002510  000244          JMP CL12
      002511  000115
0952  002512  000127  CL11    DAA
0953  002513  000003          ADDN 6
      002514  000006
0954  002515  000127  CL12    DAA
0955  002516  000256          STA 6
0956  002517  000277          MOVN MONTBL,7
      002520  002567
0957  002521  000377          LDA 7          CALCULATE MONTH POINTER
0958  002522  000067          CMA
0959  002523  000027          INA
0960  002524  000150          ADD 0
0961  002525  000347          RL
0962  002526  000347          RL
0963  002527  000273          MOVN MONLBL,3
      002530  003235
0964  002531  000153          ADD 3
0965  002532  000253          STA 3          PRINT MONTH
0966  002533  000313          DEC 3
0967  002534  000277          MOVN 4,7
      002535  000004
0968  002536  000324          CALL MEM
      002537  000052
0969  002540  000376          LDA 6
0970  002541  000107          SWAP
0971  002542  000123          ANDN H0FH
      002543  000017
0972  002544  000003          ADDN H30H
      002545  000060
0973  002546  000324          CALL PRNT
      002547  000000
0974  002550  000376          LDA 6
0975  002551  000123          ANDN H0FH
      002552  000017
0976  002553  000003          ADDN H30H
      002554  000060
0977  002555  000324          CALL PRNT
      002556  000000
0978  002557  000270          MOVN H27H,0
      002560  000047
0979  002561  000360          LDAI 0
0980  002562  000255          STA 5
0981  002563  000030          INC 0
0982  002564  000360          LDAI 0
```

```
0983  002565  000256                 STA 6
0984  002566  000203                 RET
0985  *
0986  *        TABLE
0987  *
0988  002567  000040  MONTBL    OCT 40            JAN
0989  002570  000035            OCT 35            FEB
0990  002571  000040            OCT 40            MAR
0991  002572  000037            OCT 37            APR
0992  002573  000040            OCT 40            MAY
0993  002574  000037            OCT 37            JUN
0994. 032575  000040            OCT 40            JUL
0995  002576  000040            OCT 40            AUG
0996  002577  000037            OCT 37            SEP
0997  002600  000040            OCT 40            OCT
0998  002601  000037            OCT 37            NOV
0999  002602  000040            OCT 40            DEC
1000  *
1001  *       SUBROUTINE "CNT"
1002  *
1003  002603  000357  CNT       DBNZ CNT1LK,7
      002604  000067
1004  002605  000030            INC 0
1005  002606  000370            LDA 0
1006  002607  000243            LDAA
1007  002610  000007            DCA
1008  002611  000257            STA 7
1009  002612  000375  CNT1      LDA 5
1010  002613  000003            ADDN 1
      002614  000001
1011  002615  000127            DAA
1012  002616  000255            STA 5
1013  002617  000203            RET
1014  003000                    ORG 3000B
1015  *
1016  *       MEM MUST BE ON THE
1017  *       SAME PAGE AS ASCII TABLES
1018  *
1019  *
1020  *       SUBROUTINE PRNT
1021  *
1022  003000  000205  PRNT      CLF0
1023  003001  000254            STA 4
1024  003002  000323            XORN 15B
      003003  000015
1025  003004  000226            BNZ SETFLAG
      003005  000007
1026  003006  000225            CMF0
1027  003007  000043  SETFLAG   LDAN H11H
      003010  000021
1028  003011  000072            OUT 2
```

```
003012  000076            OUTX 6
003013  000374            LDA 4
003014  000074            OUTX 4
003015  000107            SWAP
003016  000075            OUTX 5
003017  000047            CLA
003020  000076            OUTX 6
003021  000274            MOVN H3CH,4
003022  000074
003023  000017  MICRO300  INX 7
003024  000067            CMA
003025  000022            BBS DONE,0
003026  000031
003027  000354            DBNZ MICRO300,4
003030  000023
003031  000043  DONE      LDAN 1
003032  000001
003033  000076            OUTX 6
003034  000266            BF0 CR
003035  000037
003036  000203            RET
003037  000274  CR        MOVN H0FFH,4
003040  000377
003041  000043  STALL     LDAN H0FFH
003042  000377
003043  000007  M8650     DCA
003044  000000            NOP
003045  000226            BNZ M8650
003046  000043
003047  000354            DBNZ STALL,4
003050  000041
003051  000203            RET
*
*          SUBROUTINE MEM
*
003052  000033  MEM       INC 3
003053  000373            LDA 3
003054  000243            LDAA
003055  000324            CALL PRNT
003056  000000
003057  000357            DBNZ MEM,7
003060  000052
003061  000203            RET
*
*          TABLE
*
003062  000015  DATMSG    ASC \<  DATE
003063  000040
003064  000040
003065  000104
003066  000101
```

```
      003067  000124
      003070  000105
      003071  000040
      003072  000040
      003073  000040
      003074  000040
      003075  000040
1065  003076  000000  TIMMSG   ASC \0<  TIME  \
      003077  000015
      003100  000040
      003101  000040
      003102  000124
      003103  000111
      003104  000115
      003105  000105
      003106  000040
      003107  000040
1066  003110  000040  STRMSG   ASC \  <    STREAM NO. \
      003111  000040
      003112  000015
      003113  000040
      003114  000040
      003115  000040
      003116  000040
      003117  000123
      003120  000124
      003121  000122
      003122  000105
      003123  000101
      003124  000115
      003125  000040
      003126  000116
      003127  000117
      003130  000056
      003131  000040
1067  003132  000040  DBLCRMSG ASC \    <<\
      003133  000040
      003134  000040
      003135  000040
      003136  000015
      003137  000015
1068  003140  000120  PRESMESG ASC \PRES\
      003141  000122
      003142  000105
      003143  000123
1069  003144  000040  ASTT1MSG ASC \ T1 \
      003145  000124
      003146  000061
      003147  000040
1070  003150  000015  T1=MSG   ASC \<  T1 = \
      003151  000040
      003152  000040
      003153  000124
      003154  000061
      003155  000040
      003156  000075
      003157  000040
1071  003160  000040   SECT2MSG ASC \ SEC  <  T2 = \
      003161  000123
      003162  000105
      003163  000103
      003164  000040
      003165  000040
      003166  000015
      003167  000040
      003170  000040
      003171  000124
      003172  000062
      003173  000040
      003174  000075
      003175  000040
1072  003176  000040   SECPFMSG ASC \ SEC  <PLUG FACTOR =\
      003177  000123
      003200  000105
      003201  000103
      003202  000040
      003203  000040
      003204  000015
      003205  000120
      003206  000114
      003207  000125
      003210  000107
      003211  000040
      003212  000106
      003213  000101
      003214  000103
      003215  000124
      003216  000117
      003217  000122
      003220  000040
      003221  000075
1073  003222  000040   PRCNTMSG OCT 40
1074  003223  000045            OCT 45        (PERCENT SIGN)
1075  003224  000015            OCT 15
1076  003225  000040   ASTT2MSG ASC \ T2 \
      003226  000124
      003227  000062
      003230  000040
1077  003231  000040   ASTPFMSG ASC \ PF \
      003232  000120
      003233  000106
      003234  000040
```

```
1078  003235  000112  MONLBL   ASC \JAN \
      003236  000101
      003237  000116
      003240  000040
1079  003241  000106           ASC \FEB \
      003242  000105
      003243  000102
      003244  000040
1080  003245  000115           ASC \MAR \
      003246  000101
      003247  000122
      003250  000040
1081  003251  000101           ASC \APR \
      003252  000120
      003253  000122
      003254  000040
1082  003255  000115           ASC \MAY \
      003256  000101
      003257  000131
      003260  000040
1083  003261  000112           ASC \JUN \
      003262  000125
      003263  000116
      003264  000040
1084  003265  000112           ASC \JUL \
      003266  000125
      003267  000114
      003270  000040
1085  003271  000101           ASC \AUG \
      003272  000125
      003273  000107
      003274  000040
1086  003275  000123           ASC \SEP \
      003276  000105
      003277  000120
      003300  000040
1087  003301  000117           ASC \OCT \
      003302  000103
      003303  000124
      003304  000040
1088  003305  000116           ASC \NOV \
      003306  000117
      003307  000126
      003310  000040
1089  003311  000104           ASC \DEC \
      003312  000105
      003313  000103
      003314  000040
1090  003315  000040  ALARMMSG ASC \ ALARM<\
      003316  000101
      003317  000114
      003320  000101
      003321  000122
      003322  000115
      003323  000015
1091  003324  000040  STRMSCG  ASC \  START OF CYCLE<\
      003325  000040
      003326  000123
      003327  000124
      003330  000101
      003331  000122
      003332  000124
      003333  000040
      003334  000117
      003335  000106
      003336  000040
      003337  000103
      003340  000131
      003341  000103
      003342  000114
      003343  000105
      003344  000015
1092  *
1093  *
1094  *
1095  *          DATA
1096  *
1097  *
1098  *
1099  *          VARIABLES
1100  *
1101          000032  T1        EQU 32B
1102          000035  T2        EQU 35B
1103          000030  PF        EQU 30B
1104  *
1105  *          HEX CONSTANT DEFINITION
1106  *
1107          000005  H05H      EQU 5B
1108          000012  H0AH      EQU 12B
1109          000013  H0BH      EQU 13B
1110          000014  H0CH      EQU 14B
1111          000015  H0DH      EQU 15B
1112          000016  H0EH      EQU 16B
1113          000017  H0FH      EQU 17B
1114          000020  H10H      EQU 20B
1115          000021  H11H      EQU 21B
1116          000022  H12H      EQU 22B
1117          000023  H13H      EQU 23B
1118          000024  H14H      EQU 24B
1119          000025  H15H      EQU 25B
1120          000030  H18H      EQU 30B
1121          000040  H20H      EQU 40B
```

```
        000041   H21H      EQU 41B
        000042   H22H      EQU 42B
        000043   H23H      EQU 43B
        000045   H25H      EQU 45B
        000047   H27H      EQU 47B
        000050   H28H      EQU 50B
        000052   H2AH      EQU 52B
        000056   H2EH      EQU 56B
        000060   H30H      EQU 60B
        000072   H3AH      EQU 72B
        000074   H3CH      EQU 74B
        000077   H3FH      EQU 77B
        000100   H40H      EQU 100B
        000110   H48H      EQU 110B
        000120   H50H      EQU 120B
        000122   H52H      EQU 122B
        000124   H54H      EQU 124B
        000130   H58H      EQU 130B
        000131   H59H      EQU 131B
        000140   H60H      EQU 140B
        000203   H83H      EQU 203B
        000213   H8BH      EQU 213B
        000231   H99H      EQU 231B
        000357   H0EFH     EQU 357B
        000360   H0F0H     EQU 360B
        000377   H0FFH     EQU 377B
  *
  *
  *      END
  *
  *
```

APPENDIX D

PFMEC SYSTEM LISTINGS WITHOUT PRINTER DRIVER

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```
******
*
*
*                    PLUGGING FACTOR MONITOR
*
*
***********
***********
***********
*
*                    POWER-UP VECTOR
*
                                      ORG 0B
          000000    RESET             NOP
000001    000004                      JMP INITIAL
000002    000034
*
*                    EXTERNAL INTERRUPT VECTOR
*
000003    000000    EXTINT            NOP
000004    000000                      NOP
000005    000004                      JMP *
000006    000005
*
*                    TIMER/COUNTER INTERRUPT VECTOR
*
* INCREMENT A TIMER IN REGISTERS 2,3, &4
* (BANK 0).  INCREMENTS BCD COUNT BY 20
* MSEC FOR EACH TIMER/COUNTER INTERRUPT.
000007    000065    T/CINT            DITC
000010    000305                      SR0
000011    000251                      STA 1
000012    000227                      CLC
000013    000043                      LDAN 2
000014    000002
000015    000152                      ADD 2
000016    000127                      DAA
000017    000252                      STA 2
000020    000346                      BCC RETURN
000021    000031
000022    000047                      CLA
000023    000173                      ADC 3
000024    000127                      DAA
000025    000253                      STA 3
000026    000346                      BCC RETURN
000027    000031
000030    000034                      INC 4
000031    000371    RETURN            LDA 1
000032    000045                      ENTC
000033    000223                      RETR
*
```

```
0047  *              INITIALIZATION
0048  *
0049  000034  000277  INITIAL  MOVN 1,7
      000035  000001
0050  000036  000064           CALL DELAY
      000037  000322
0051  000040  000043           LDAN H10H
      000041  000020
0052  000042  000072           OUT 2
0053  000043  000074           OUTX 4
0054  000044  000075           OUTX 5
0055  000045  000043           LDAN 1
      000046  000001
0056  000047  000076           OUTX 6
0057  000050  000047           CLA
0058  000051  000043           LDAN H20H
      000052  000040
0059  000053  000072           OUT 2
0060  000054  000074           OUTX 4
0061  000055  000075           OUTX 5
0062  000056  000076           OUTX 6
0063  000057  000077           OUTX 7
0064  000060  000043           LDAN H30H
      000061  000060
0065  000062  000072           OUT 2
0066  000063  000074           OUTX 4
0067  000064  000043           LDAN H40H
      000065  000100
0068  000066  000072           OUT 2
0069  000067  000074           OUTX 4
0070  000070  000075           OUTX 5
0071  000071  000076           OUTX 6
0072  000072  000043           LDAN H50H
      000073  000120
0073  000074  000072           OUT 2
0074  000075  000074           OUTX 4
0075  000076  000076           OUTX 6
0076  000077  000277           MOVN H59H,7
      000100  000131
0077  000101  000064           CALL DELAY
      000102  000322
0078  000103  000011           IN 1
0079  000104  000107           SWAP
0080  000105  000067           CMA
0081  000106  000123           ANDN 7
      000107  000007
0082  000110  000255           STA 5
0083  *
0084  *         START OF PROGRAM
0085  *
0086  000111  000375  START    LDA 5
```

```
0087  000112  000067            CMA
0088  000113  000003            ADDN 7
      000114  000007
0089  000115  000067            CMA
0090  000116  000362            BBS OVER1,7
      000117  000122
0091  000120  000275            MOVN 0,5
      000121  000000
0092  000122  000375  OVER1     LDA 5
0093  000123  000226            BNZ OVER2
      000124  000126
0094  000125  000035            INC 5
0095  000126  000375  OVER2     LDA 5
0096  000127  000103            IORN H0F0H
      000130  000360
0097  000131  000071            OUT 1
0098  000132  000043            LDAN H58H
      000133  000130
0099  000134  000072            OUT 2
0100  000135  000076            OUTX 6
0101  000136  000047            CLA
0102  000137  000076            OUTX 6
0103  000140  000375            LDA 5
0104  000141  000323            XORN 5
      000142  000005
0105  000143  000306            BZ FIVE
      000144  000170
0106  000145  000375            LDA 5
0107  000146  000323            XORN 6
      000147  000006
0108  000150  000306            BZ SIX
      000151  000200
0109  000152  000375            LDA 5
0110  000153  000256            STA 6
0111  000154  000043            LDAN H30H
      000155  000060
0112  000156  000072            OUT 2
0113  000157  000017            INX 7
0114  000160  000147  LOOP2     RRC
0115  000161  000356            DBNZ LOOP2,6
      000162  000160
0116  000163  000366            BCS ACTIVE
      000164  000210
0117  000165  000035  INACTIVE  INC 5
0118  000166  000004            JMP START
      000167  000111
0119  000170  000043  FIVE      LDAN H40H
      000171  000100
0120  000172  000072            OUT 2
0121  000173  000017            INX 7
0122  000174  000022            BBS ACTIVE,0
```

```
      000175  000210
0123  000176  000004            JMP INACTIVE
      000177  000165
0124  000200  000043  SIX       LDAN H40H
      000201  000100
0125  000202  000072            OUT 2
0126  000203  000017            INX 7
0127  000204  000062            BBS ACTIVE,1
      000205  000210
0128  000206  000004            JMP INACTIVE
      000207  000165
0129  000210  000043  ACTIVE    LDAN H20H
      000211  000040
0130  000212  000072            OUT 2
0131  000213  000375            LDA 5
0132  000214  000227            CLC
0133  000215  000367            RLC
0134  000216  000164            CALL PRINT
      000217  000167
0135  000220  000043  ADVANCE   LDAN H48H
      000221  000110
0136  000222  000072            OUT 2
0137  000223  000076            OUTX 6
0138  *
0139  *               NEW PAPER FAULT DETECTION
0140  *
0141  000224  000047            CLA             START TIMER
0142  000225  000252            STA 2
0143  000226  000253            STA 3
0144  000227  000254            STA 4
0145  000230  000142            STAT
0146  000231  000125            TIME
0147  000232  000045            ENTC
0148  000233  000043            LDAN H10H       CHECK OPTIC INPUT
      000234  000020
0149  000235  000072            OUT 2
0150  000236  000017            INX 7
0151  000237  000062            BBS ADV1,1
      000240  000275
0152  000241  000017  ADV2      INX 7
0153  000242  000062            BBS ANEXT,1
      000243  000312
0154  000244  000373            LDA 3           CHECK TIMER
0155  000245  000323            XORN 4
      000246  000004
0156  000247  000226            BNZ ADV2
      000250  000241
0157  000251  000065  ALARM     DITC            STOP MOTOR
0158  000252  000145            STOP
0159  000253  000043            LDAN H40H
      000254  000100
```

```
0160  000255  000072                OUT 2
0161  000256  000076                OUTX 6
0162  000257  000043                LDAN H25H       SET ALARM
      000260  000045
0163  000261  000072                OUT 2
0164  000262  000077                OUTX 7
0165  000263  000047                CLA
0166  000264  000077                OUTX 7
0167  000265  000043                LDAN H40H       WAIT FOR ALARM RESET
      000266  000100
0168  000267  000072                OUT 2
0169  000270  000017                INX 7
0170  000271  000122                BBS *-1,2
      000272  000270
0171  000273  000004                JMP ADVANCE
      000274  000220
0172  000275  000017  ADV1          INX 7           CHECK OPTIC INPUT
0173  000276  000067                CMA
0174  000277  000062                BBS ANEXT,1
      000300  000312
0175  000301  000373  ADV3          LDA 3           CHECK TIMER
0176  000302  000323                XORN 4
      000303  000004
0177  000304  000226                BNZ ADV1
      000305  000275
0178  000306  000004                JMP ALARM
      000307  000251
0179  000310  000044  GOOD1LK       JMP GOOD1
      000311  000030
0180  000312  000373  ANEXT         LDA 3
0181  000313  000323                XORN 3
      000314  000003
0182  000315  000226                BNZ ANEXT
      000316  000312
0183  000317  000065                DITC            STOP MOTOR
0184  000320  000145                STOP
0185  000321  000043                LDAN H40H
      000322  000100
0186  000323  000072                OUT 2
0187  000324  000076                OUTX 6
0188  000325  000276                MOVN 6,6
      000326  000006
0189  000327  000164                CALL PRINT
      000330  000167
0190  000331  000064  OKAY          CALL VALVEON
      000332  000340
0191  000333  000277                MOVN H60H,7
      000334  000140
0192  000335  000064                CALL DELAY
      000336  000322
0193  000337  000043                LDAN H21H       "LOWER HEAD"
```

```
        000340  000041
0194    000341  000072            OUT 2
0195    000342  000216            IORX 6
0196    000343  000277            MOVN 3,7
        000344  000003
0197    000345  000064            CALL DELAY
        000346  000322
0198    000347  000043            LDAN 4
        000350  000004
0199    000351  000215            IORX 5
0200    000352  000277            MOVN 5,7
        000353  000005
0201    000354  000064            CALL DELAY
        000355  000322
0202    000356  000043            LDAN 8
        000357  000010
0203    000360  000215            IORX 5
0204    000361  000276            MOVN H0FFH,6
        000362  000377
0205    000363  000270            MOVN H20H,0
        000364  000040
0206    000365  000124            CALL TIMEOUT
        000366  000130
0207    000367  000166            BF1 GOOD1LK
        000370  000310
0208    000371  000270  PRESSURE  MOVN 1,6
        000372  000001
0209    000373  000164            CALL PRINT
        000374  000167
0210    000375  000043  NOPRINT1  LDAN H22H
        000376  000042
0211    000377  000072            OUT 2
0212    000400  000077            OUTX 7
0213    000401  000047            CLA
0214    000402  000077            OUTX 7
0215    000403  000124  INSERT    CALL SONALERT
        000404  000040
0216    000405  000325            SR1
0217    000406  000270            MOVN 9,0
        000407  000011
0218    000410  000271            MOVN H99H,1
        000411  000231
0219    000412  000305            SR0
0220    000413  000064            CALL LATCH12
        000414  000375
0221    000415  000124            CALL CLOSEDWN
        000416  000047
0222    000417  000035            INC 5
0223    000420  000004            JMP START
        000421  000111
0224    000422  000044  GOONLNK   JMP GOON
```

```
      000423  000057
0225  000424  000004  PRESSLK   JMP PRESSURE
      000425  000371
0226  000426  000044  NOPRNTLK  JMP NOPRINT2
      000427  000046
0227  000430  000277  GOOD1     MOVN 1,7
      000431  000001
0228  000432  000124            CALL THUMDIAL
      000433  000100
0229  000434  000124            CALL TIMEOUT
      000435  000130
0230  000436  000266            BF0 PRESSLK
      000437  000024
0231  000440  000166            BF1 GOONLNK
      000441  000022
0232  000442  000276            MOVN 2,6
      000443  000002
0233  000444  000164            CALL PRINT
      000445  000167
0234  000446  000043  NOPRINT2  LDAN H12H
      000447  000022
0235  000450  000072            OUT 2
0236  000451  000216            IORX 6
0237  000452  000043            LDAN 15B
      000453  000015
0238  000454  000236            ANDX 6
0239  000455  000044            JMP INSERT
      000456  000003
0240  000457  000043  GOON      LDAN H27H
      000460  000047
0241  000461  000072            OUT 2
0242  000462  000235            ANDX 5
0243  000463  000270            MOVN T1,0
      000464  000032
0244  000465  000124            CALL STORE
      000466  000067
0245  000467  000043            LDAN H54H
      000470  000124
0246  000471  000072            OUT 2
0247  000472  000074            OUTX 4
0248  000473  000015            INX 5
0249  000474  000103            IORN H0F0H
      000475  000360
0250  000476  000067            CMA
0251  000477  000250            STA 0
0252  000500  000043            LDAN 5
      000501  000005
0253  000502  000074            OUTX 4
0254  000503  000015            INX 5
0255  000504  000103            IORN H0F0H
      000505  000360
```

```
0256   000506   000067              CMA
0257   000507   000256              STA 6
0258   000510   000036              INC 6
0259   000511   000370              LDA 0
0260   000512   000226              BNZ OP2
       000513   000117
0261   000514   000316              DEC 6
0262   000515   000270   OP1        MOVN H0AH,0
       000516   000012
0263   000517   000277   OP2        MOVN H60H,7
       000520   000140
0264   000521   000064              CALL DELAY
       000522   000322
0265   000523   000350              DBNZ OP2,0
       000524   000117
0266   000525   000356              DBNZ OP1,6
       000526   000115
0267   000527   000043              LDAN H28H
       000530   000050
0268   000531   000072              OUT 2
0269   000532   000215              IORX 5
0270   000533   000276              MOVN H0FFH,6
       000534   000377
0271   000535   000270              MOVN H20H,0
       000536   000040
0272   000537   000124              CALL TIMEOUT
       000540   000130
0273   000541   000166              BF1 GOOD2
       000542   000145
0274   000543   000004   PRESLNK    JMP PRESSURE
       000544   000371
0275   000545   000277   GOOD2      MOVN 6,7
       000546   000006
0276   000547   000124              CALL THUMDIAL
       000550   000100
0277   000551   000124              CALL TIMEOUT
       000552   000130
0278   000553   000276              MOVN 0,6
       000554   000000
0279   000555   000266              BF0 PRESLNK
       000556   000143
0280   000557   000166              BF1 GOONA
       000560   000174
0281   000561   000124              CALL SONALERT
       000562   000040
0282   000563   000043              LDAN H14H
       000564   000024
0283   000565   000072              OUT 2
0284   000566   000216              IORX 6
0285   000567   000043              LDAN 13B
       000570   000013
```

```
0286  000571  000236             ANDX 6
0287  000572  000276             MOVN 4,6
      000573  000004
0288  000574  000270  GOONA      MOVN T2,0
      000575  000035
0289  000576  000124             CALL STORE
      000577  000067
0290  000600  000124             CALL CLOSEDWN
      000601  000047
0291  000602  000124             CALL P.F.CALC
      000603  000261
0292  000604  000305             SR0
0293  000605  000043             LDAN H59H
      000606  000131
0294  000607  000072             OUT 2
0295  000610  000074             OUTX 4
0296  000611  000015             INX 5
0297  000612  000257             STA 7
0298  000613  000043             LDAN H0AH
      000614  000012
0299  000615  000074             OUTX 4
0300  000616  000015             INX 5
0301  000617  000107             SWAP
0302  000620  000117             IOR 7
0303  000621  000067             CMA
0304  000622  000257             STA 7
0305  000623  000270             MOVN PF,0
      000624  000030
0306  000625  000360             LDAI 0
0307  000626  000107             SWAP
0308  000627  000123             ANDN H0F0H
      000630  000360
0309  000631  000251             STA 1
0310  000632  000030             INC 0
0311  000633  000360             LDAI 0
0312  000634  000107             SWAP
0313  000535  000123             ANDN H0FH
      000636  000017
0314  000637  000111             IOR 1
0315  000640  000251             STA 1
0316  000641  000270             MOVN 8,0
      000542  000010
0317  000543  000377  LOOP4      LDA 7
0318  000644  000367             RLC
0319  000645  000257             STA 7
0320  000646  000366             BCS SET
      000547  000261
0321  000650  000044  ALARMLK    JMP ALARMS
      000651  000270
0322  000652  000371             LDA 1
0323  000553  000367             RLC
```

```
0324  000554  000251            STA 1
0325  000555  000366            BCS ALARMLK
      000556  000250
0326  000557  000044            JMP ENDLOOP
      000560  000266
0327  000561  000371  SET       LDA 1
0328  000562  000367            RLC
0329  000563  000251            STA 1
0330  000564  000346            BCC CLEAR
      000565  000306
0331  000566  000350  ENDLOOP   DBNZ LOOP4,0
      000567  000243
0332  000570  000124  ALARMS    CALL SONALERT
      000571  000040
0333  000572  000043            LDAN H18H
      000573  000030
0334  000574  000072            OUT 2
0335  000575  000216            IORX 6
0336  000576  000043            LDAN 7
      000577  000007
0337  000700  000236            ANDX 6
0338  000701  000376            LDA 6
0339  000702  000122            BBS CLEAR,2
      000703  000306
0340  000704  000276            MOVN 5,6
      000705  000005
0341  000706  000064  CLEAR     CALL LATCH12
      000707  000375
0342  000710  000376            LDA 6
0343  000711  000226            BNZ TOOLATE
      000712  000315
0344  000713  000276            MOVN 3,6
      000714  000003
0345  000715  000164  TOOLATE   CALL PRINT
      000716  000167
0346  000717  000035  NOPRINT3  INC 5
0347  000720  000004            JMP START
      000721  000111
0348  *
0349  *          SUBROUTINE DELAY
0350  *
0351  * DELAYS FOR BCD COUNT (IN SECONDS)
0352  * PASSED IN R7
0353  000722  000047  DELAY     CLA
0354  000723  000252            STA 2
0355  000724  000253            STA 3
0356  000725  000254            STA 4
0357  000726  000142            STAT
0358  000727  000125            TIME
0359  000730  000045            ENTC
0360  000731  000373  LOOP0     LDA 3
```

```
000732  000337                      XOR 7
000733  000226                      BNZ LOOP0
000734  000331
000735  000065                      DITC
000736  000145                      STOP
000737  000223                      RETR
*
*          SUBROUTINE VALVE ON
*
* TURNS ON APPROPRIATE STREAM INLET
* VALVE DEPENDING ON STREAM COUNT IN
* REGISTER #5.
000740  000043  VALVEON    LDAN H20H
000741  000040
000742  000072             OUT 2
000743  000227             CLC
000744  000247             CMC
000745  000375             LDA 5
000746  000256             STA 6
000747  000047             CLA
000750  000367  LOOP1      RLC
000751  000356             DBNZ LOOP1,6
000752  000350
000753  000214             IORX 4
000754  000107             SWAP
000755  000215             IORX 5
000756  000107             SWAP
000757  000234             ANDX 4
000760  000107             SWAP
000761  000235             ANDX 5
000762  000223  R2D2       RETR
*
*          SUBROUTINE STROBE
*
* STROBES IN 12-BIT CMOS DATA LATCH.
* USED BY SUBROUTINE "12-BIT LATCH".
000763  000043  STROBE     LDAN H28H
000764  000050
000765  000072             OUT 2
000766  000077             OUTX 7
000767  000047             CLA
000770  000077             OUTX 7
000771  000043             LDAN H40H
000772  000100
000773  000072             OUT 2
000774  000223             RETR
*
*          SUBROUTINE 12-BIT LATCH
*
* OUTPUTS PLUG FACTOR TO 12-BIT CMOS
* LTCH (I.E. LED DISPLAYS & CURRENT
0407  * OUTPUTS).  DATA IN RAM LOCATIONS
0408  * 24 & 25.
0409  000775  000043  LATCH12  LDAN H40H
      000776  000100
0410  000777  000072           OUT 2
0411  001000  000375           LDA 5
0412  001001  000075           OUTX 5
0413  001002  000270           MOVN PF,0
      001003  000030
0414  001004  000360           LDAI 0
0415  001005  000074           OUTX 4
0416  001006  000043           LDAN 4
      001007  000004
0417  001010  000076           OUTX 6
0418  001011  000064           CALL STROBE
      001012  000363
0419  001013  000030           INC 0
0420  001014  000360           LDAI 0
0421  001015  000107           SWAP
0422  001016  000074           OUTX 4
0423  001017  000043           LDAN 2
      001020  000002
0424  001021  000076           OUTX 6
0425  001022  000064           CALL STROBE
      001023  000363
0426  001024  000360           LDAI 0
0427  001025  000074           OUTX 4
0428  001026  000043           LDAN 1
      001027  000001
0429  001030  000076           OUTX 6
0430  001031  000064           CALL STROBE
      001032  000363
0431  001033  000047           CLA
0432  001034  000074           OUTX 4
0433  001035  000075           OUTX 5
0434  001036  000076           OUTX 6
0435  001037  000223           RETR
0436  *
0437  *       SUBROUTINE SONALERT
0438  *
0439  * TURNS ON SONALERT AND ALARM RELAY
0440  *
0441  001040  000043  SONALERT LDAN 24H
      001041  000044
0442  001042  000072           OUT 2
0443  001043  000077           OUTX 7
0444  001044  000047           CLA
0445  001045  000077           OUTX 7
0445  001046  000223           RETR
0447  *
0448  *       SUBROUTINE CLOSE DOWN
```

```
*
* OPENS FILTRATE TANK DRAIN VALVE,
* BYPASS VALVE, AND MOVES FILTER
* HEAD UP.  DELAYS FOR 3 SECONDS.
* SHUTS OFF ALL STREAM INLET VALVES.
001047  000043  CLOSEDWN LDAN H23H
001050  000043
001051  000072           OUT 2
001052  000235           ANDX 5
001053  000277           MOVN H10H,7
001054  000020
001055  000064           CALL DELAY
001056  000322
001057  000043           LDAN H0EH
001060  000016
001061  000236           ANDX 6
001062  000277           MOVN 1,7
001063  000001
001064  000064           CALL DELAY
001065  000322
001066  000203           RET
*
*        SUBROUTINE STORE
*
* TRANSFERS TIME COUNT (IN SECONDS)
* TO T1 OR T2.  IF ARGUMENT IN R0
* IS "1A", THEN T1       IF "1D", THEN T2.
001067  000374  STORE    LDA 4
001070  000240           STAI 0
001071  000030           INC 0
001072  000373           LDA 3
001073  000240           STAI 0
001074  000030           INC 0
001075  000372           LDA 2
001076  000240           STAI 0
001077  000223           RETR
*
*        SUBROUTINE THUMDIAL
*
001100  000043  THUMDIAL LDAN H50H
001101  000120
001102  000072           OUT 2
001103  000377           LDA 7
001104  000074           OUTX 4
001105  000015           INX 5
001106  000250           STA 0
001107  000037           INC 7
001110  000377           LDA 7
001111  000074           OUTX 4
001112  000015           INX 5
001113  000107           SWAP
```

```
0493  001114  000110           IOR 0
0494  001115  000067           CMA
0495  001116  000250           STA 0
0496  001117  000037           INC 7
0497  001120  000377           LDA 7
0498  001121  000074           OUTX 4
0499  001122  000015           INX 5
0500  001123  000067           CMA
0501  001124  000123           ANDN H0FH
      001125  000017
0502  001126  000256           STA 6
0503  001127  000223           RETR
0504  *
0505  *       SUBROUTINE TIMEOUT
0506  *
0507  001130  000245  TIMEOUT  CLF1
0508  001131  000043           LDAN H0FFH
      001132  000377
0509  001133  000336           XOR 6
0510  001134  000226           BNZ HOP1
      001135  000137
0511  001136  000265           CMF1
0512  001137  000166  HOP1     BF1 HOP2
      001140  000145
0513  001141  000277           MOVN 1,7
      001142  000001
0514  001143  000064           CALL DELAY
      001144  000322
0515  001145  000047  HOP2     CLA
0516  001146  000252           STA 2
0517  001147  000253           STA 3
0518  001150  000254           STA 4
0519  001151  000142           STAT
0520  001152  000125           TIME
0521  001153  000045           ENTC
0522  001154  000206  LOOPY    BIL WATER
      001155  000244
0523  001156  000166           BF1 SKIPY
      001157  000226
0524  001160  000043           LDAN H10H
      001161  000020
0525  001162  000072           OUT 2
0526  001163  000017           INX 7
0527  001164  000162           BBS SKIPY,3
      001165  000226
0528  001166  000043           LDAN 8
      001167  000010
0529  001170  000075           OUTX 5
0530  001171  000047           CLA
0531  001172  000075           OUTX 5
0532  001173  000043           LDAN H40H
```

```
      001174  000100
0533  001175  000072            OUT 2
0534  001176  000017  AGAIN     INX 7
0535  001177  000162            BBS AGAIN,3
      001200  000176
0536  001201  000043            LDAN H30H
      001202  000060
0537  001203  000072            OUT 2
0538  001204  000016            INX 6
0539  001205  000067            CMA
0540  001206  000123            ANDN H0FH
      001207  000017
0541  001210  000323            XORN 9
      001211  000011
0542  001212  000226            BNZ PROBLEM
      001213  000222
0543  001214  000015            INX 5
0544  001215  000067            CMA
0545  001216  000162            BBS SKIPY,3
      001217  000226
0546  001220  000122            BBS SKIPY,2
      001221  000226
0547  001222  000205  PROBLEM   CLF0
0548  001223  000225            CMF0
0549  001224  000104            JMP ENTER
      001225  000246
0550  001226  000205  SKIPY     CLF0
0551  001227  000166            BF1 HOP3
      001230  000235
0552  001231  000374            LDA 4
0553  001232  000336            XOR 6
0554  001233  000226            BNZ LOOPY
      001234  000154
0555  001235  000373  HOP3      LDA 3
0556  001236  000330            XOR 0
0557  001237  000226            BNZ LOOPY
      001240  000154
0558  001241  000245            CLF1
0559  001242  000104            JMP ENTER
      001243  000246
0560  001244  000245  WATER     CLF1
0561  001245  000265            CMF1
0562  001246  000065  ENTER     DITC
0563  001247  000145            STOP
0564  001250  000373            LDA 3
0565  001251  000003            ADDN 1
      001252  000001
0566  001253  000127            DAA
0567  001254  000253            STA 3
0568  001255  000346            BCC HOP4
      001256  000260
```

```
0569  001257  000034             INC 4
0570  001260  000203  HOP4       RET
0571  *
0572  *          SUBROUTINE P.F.CALC
0573  *
0574  * CALCULATES THE PLUGGING FACTOR
0575  * BY PERFORMING:[100-(100*(T1TT2))]
0576  001261  000325  P.F.CALC SR1               IF T2<OR=T1, SET PF=00.0
0577  001262  000227             CLC
0578  001263  000372             LDA 2
0579  001264  000067             CMA
0580  001265  000155             ADD 5
0581  001266  000067             CMA
0582  001267  000306             BZ .A
      001270  000275
0583  001271  000366             BCS .C
      001272  000307
0584  001273  000346             BCC .B
      001274  000303
0585  001275  000227  .A         CLC
0586  001276  000373             LDA 3
0587  001277  000067             CMA
0588  001300  020156             ADD 6
0589  001301  000366             BCS .C
      001302  000307
0590  001303  000047  .B         CLA
0591  001304  000250             STA 0
0592  001305  000251             STA 1
0593  001306  000203             RET
0594  001307  000047  .C         CLA              INITIALIZE QUOTIENT
0595  001310  000250             STA 0
0596  001311  000251             STA 1
0597  001312  000305             SR0
0598  001313  000270             MOVN T1,0    SAVE T1
      001314  000032
0599  001315  000271             MOVN H20H,1
      001316  000040
0600  001317  000272             MOVN 3,2
      001320  000003
0601  001321  000164             CALL SAVE
      001322  000117
0602  001323  000274             MOVN 4,4     INITIALIZE DIGIT COUNTER
      001324  000004
0603  001325  000305  SUBTRACT SR0            SAVE PARTIAL DIVIDEND
0604  001326  000270             MOVN T1,0
      001327  000032
0605  001330  000271             MOVN H23H,1
      001331  000043
0606  001332  000272             MOVN 3,2
      001333  000003
0607  001334  000164             CALL SAVE
      001335  000117
```

```
0608  001336  000325             SR1              SUBTRACT T2 FROM T1
0609  001337  000374             LDA 4
0610  001340  000067             CMA
0611  001341  000157             ADD 7
0612  001342  000164             CALL DAA
      001343  000126
0613  001344  000254             STA 4
0614  001345  000373             LDA 3
0615  001346  000067             CMA
0616  001347  000176             ADC 6
0617  001350  000164             CALL DAA
      001351  000126
0618  001352  000253             STA 3
0619  001353  000372             LDA 2
0620  001354  000067             CMA
0621  001355  000175             ADC 5
0622  001356  000164             CALL DAA
      001357  000126
0623  001360  000252             STA 2
0624  001361  000000             NOP
0625  001362  000000             NOP
0626  001363  000000             NOP
0627  001364  000000             NOP
0628  001365  000000             NOP
0629  001366  000366             BCS RESTORE      TEST FOR BORROW
      001367  000373
0630  001370  000031             INC 1            INCREMENT QUOTIENT
0631  001371  000104             JMP SUBTRACT
      001372  000325
0632  001373  000305  RESTORE    SR0              RESTORE PARTIAL DIVIDEND
0633  001374  000270             MOVN H23H,0
      001375  000043
0634  001376  000271             MOVN T1,1
      001377  000032
0635  001400  000272             MOVN 3,2
      001401  000003
0636  001402  000164             CALL SAVE
      001403  000117
0637  001404  000325  SHIFT      SR1              SHIFT THE PARTIAL DIVIDEND
0638  001405  000372             LDA 2
0639  001406  000123             ANDN H0FH
      001407  000017
0640  001410  000107             SWAP
0641  001411  000252             STA 2
0642  001412  000373             LDA 3
0643  001413  000123             ANDN H0F0H
      001414  000360
0644  001415  000107             SWAP
0645  001416  000112             IOR 2
0646  001417  000252             STA 2
0647  001420  000373             LDA 3
```

```
0648  001421  000123            ANDN H0FH
      001422  000017
0649  001423  000107            SWAP
0650  001424  000253            STA 3
0651  001425  000374            LDA 4
0652  001426  000123            ANDN H0F0H
      001427  000360
0653  001430  000107            SWAP
0654  001431  000113            IOR 3
0655  001432  000253            STA 3
0656  001433  000374            LDA 4
0657  001434  000123            ANDN H0FH
      001435  000017
0658  001436  000107            SWAP
0659  001437  000254            STA 4
0660  001440  000305            SR0             TEST FOR COMPLETION
0661  001441  000354            DBNZ SHFTQ,4
      001442  000045
0662  001443  000144            JMP SUB100
      001444  000070
0663  001445  000325  SHFTQ     SR1             SHIFT QUOTIENT LEFT
0664  001446  000370            LDA 0
0665  001447  000123            ANDN H0FH
      001450  000017
0666  001451  000107            SWAP
0667  001452  000250            STA 0
0668  001453  000371            LDA 1
0669  001454  000123            ANDN H0F0H
      001455  000360
0670  001456  000107            SWAP
0671  001457  000110            IOR 0
0672  001460  000250            STA 0
0673  001461  000371            LDA 1
0674  001462  000123            ANDN H0FH
      001463  000017
0675  001464  000107            SWAP
0676  001465  000251            STA 1
0677  001466  000104            JMP SUBTRACT
      001467  000325
0678  001470  000325  SUB100    SR1             SUBTRACT RESULT FROM 100
0679  001471  000043            LDAN H0FFH
      001472  000377
0680  001473  000151            ADD 1
0681  001474  000164            CALL DAA
      001475  000126
0682  001476  000251            STA 1
0683  001477  000043            LDAN H0EFH
      001500  000357
0684  001501  000170            ADC 0
0685  001502  000164            CALL DAA
      001503  000126
```

```
001504  000250              STA 0
001505  000305              SR0               RESTORE T1
001506  000270              MOVN H20H,0
001507  000040
001510  000271              MOVN T1,1
001511  000032
001512  000272              MOVN 3,2
001513  000003
001514  000164              CALL SAVE
001515  000117
001516  000203              RET
*
*         SUBROUTINE SAVE
*
* R0= FROM ADDRESS
* R1= TO ADDRESS
* R2= # OF LOCATIONS SAVED
001517  000360  SAVE        LDAI 0
001520  000241              STAI 1
001521  000030              INC 0
001522  000031              INC 1
001523  000352              DBNZ SAVE,2
001524  000117
001525  000203              RET
*
*         SUBROUTINE DAA
*
* PERFORMS A DECIMAL ADJUST AS PART
* OF A BCD SUBTRACTION.
001526  000245  DAA         CLF1              SAVE CARRY
001527  000305              SR0
001530  000252              STA 2
001531  000307              LDAS
001532  000346              BCC CNSET
001533  000135
001534  000265              CMF1
001535  000322  CNSET       BBS ACSET,6
001536  000141
001537  000144              JMP CCHECK
001540  000145
001541  000372  ACSET       LDA 2             AC SET ADD 6
001542  000003              ADDN 6
001543  000006
001544  000252              STA 2
001545  000166  CCHECK      BF1 CSET
001546  000151
001547  000144              JMP RESTRC
001550  000155
001551  000372  CSET        LDA 2             CARRY SET ADD 60H
001552  000003              ADDN H60H
001553  000140
```

```
0725  001554  000252            STA 2
0726  001555  000372  RESTRC    LDA 2
0727  001556  000325            SR1
0728  001557  000227            CLC                RESTORE CARRY
0729  001560  000166            BF1 SETC
      001561  000164
0730  001562  000144            JMP OUT
      001563  000165
0731  001564  000247  SETC      CMC
0732  001565  000067  OUT       CMA                COMPLEMENT RESULT
0733  001566  000203            RET
0734  *
0735  *       SUBROUTINE PRINT
0736  *
0737  001567  000203  PRINT     RET
0738  *
0739  *
0740  *
0741  *       DATA
0742  *
0743  *
0744  *
0745  *       VARIABLES
0746  *
0747          000032  T1        EQU 32B
0748          000035  T2        EQU 35B
0749          000030  PF        EQU 30B
0750  *
0751  *       HEX CONSTANT DEFINITION
0752  *
0753          000012  H0AH      EQU 12B
0754          000013  H0BH      EQU 13B
0755          000014  H0CH      EQU 14B
0756          000015  H0DH      EQU 15B
0757          000016  H0EH      EQU 16B
0758          000017  H0FH      EQU 17B
0759          000020  H10H      EQU 20B
0760          000021  H11H      EQU 21B
0761          000022  H12H      EQU 22B
0762          000024  H14H      EQU 24B
0763          000025  H15H      EQU 25B
0764          000030  H18H      EQU 30B
0765          000040  H20H      EQU 40B
0766          000041  H21H      EQU 41B
0767          000042  H22H      EQU 42B
0768          000043  H23H      EQU 43B
0769          000045  H25H      EQU 45B
0770          000047  H27H      EQU 47B
0771          000050  H28H      EQU 50B
0772          000052  H24H      EQU 52B
0773          000056  H2EH      EQU 56B
```

```
                000060  H30H     EQU 60B
                000072  H3AH     EQU 72B
                000074  H3CH     EQU 74B
                000100  H40H     EQU 100B
                000110  H48H     EQU 110B
                000120  H50H     EQU 120B
                000122  H52H     EQU 122B
                000124  H54H     EQU 124B
                000130  H58H     EQU 130B
                000131  H59H     EQU 131B
                000140  H60H     EQU 140B
                000203  H83H     EQU 203B
                000213  H8BH     EQU 213B
                000231  H99H     EQU 231B
                000357  H0EFH    EQU 357B
                000360  H0F0H    EQU 360B
                000377  H0FFH    EQU 377B
   *
   *
   *              END
   *
   *
```

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APPENDIX E

PRINTER TEST LISTINGS

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```
*
**********
*
*
*        PLUGGING FACTOR MONITOR\WITH PRINT
*
*
**********
**********
**********
*
*        POWER-UP VECTOR
*
                          ORG 0B
        000000  RESET     NOP
000001  000004            JMP INITIAL
000002  000034
*
*        EXTERNAL INTERRUPT VECTOR
*
000003  000000  EXTINT    NOP
000004  000000            NOP
000005  000004            JMP *
000006  000005
*
*        TIMER/COUNTER INTERRUPT VECTOR
*
* INCREMENT A TIMER IN REGISTERS 2,3, &4
* (BANK 0). INCREMENTS BCD COUNT BY 20
* MSEC FOR EACH TIMER/COUNTER INTERRUPT.
000007  000065  T/CINT    DITC
000010  000305            SR0
000011  000251            STA 1
000012  000227            CLC
000013  000043            LDAN 2
000014  000002
000015  000152            ADD 2
000016  000127            DAA
000017  000252            STA 2
000020  000346            BCC RETURN
000021  000031
000022  000047            CLA
000023  000173            ADC 3
000024  000127            DAA
000025  000253            STA 3
000026  000346            BCC RETURN
000027  000031
000030  000034            INC 4
000031  000371  RETURN    LDA 1
000032  000045            ENTC
000033  000223            RETR
```

```
0047  *
0048  *            INITIALIZATION
0049  *
0050  000034  000000  INITIAL   NOP
0051  000035  000275  PRNTEST   MOVN 7,5
      000036  000007
0052  000037  000270            MOVN H18H,0
      000040  000030
0053  000041  000043            LDAN H0FFH
      000042  000377
0054  000043  000240            STAI 0
0055  000044  000270  REP       MOVN H18H,0
      000045  000030
0056  000046  000227            CLC
0057  000047  000360            LDAI 0
0058  000050  000276            MOVN 32,6
      000051  000040
0059  000052  000251            STA 1
0060  000053  000323            XORN H99H
      000054  000231
0061  000055  000226            BNZ PRN1
      000056  000062
0062  000057  000043            LDAN H0FFH
      000060  000377
0063  000061  000251            STA 1
0064  000062  000371  PRN1      LDA 1
0065  000063  000003            ADDN 1
      000064  000001
0066  000065  000346            BCC PRN2
      000066  000070
0067  000067  000027            INA
0068  000070  000107  PRN2      SWAP
0069  000071  000027            INA
0070  000072  000240  PRN3      STAI 0
0071  000073  000030            INC 0
0072  000074  000356            DBNZ PRN3,6
      000075  000072
0073  000076  000355            DBNZ PRN4,5
      000077  000102
0074  000100  000275            MOVN 6,5
      000101  000006
0075  000102  000043  PRN4      LDAN H30H
      000103  000060
0076  000104  000072            OUT 2
0077  000105  000017            INX 7
0078  000106  000251            STA 1
0079  000107  000043            LDAN H40H
      000110  000100
0080  000111  000072            OUT 2
0081  000112  000017            INX 7
0082  000113  000123            ANDN 3
```

```
     000114  000303
0083 000115  000107           SWAP
0084 000116  000111           IOR 1
0085 000117  000271           MOVN 6,1
     000120  000006
0086 000121  000276           MOVN 0,6
     000122  000000
0087 000123  000227           CLC
0088 000124  000147  PRN5     RRC
0089 000125  000036           INC 6
0090 000126  000366           BCS PRN6
     000127  000134
0091 000130  000351           DBNZ PRN5,1
     000131  000124
0092 000132  000004           JMP REP
     000133  000044
0093 000134  000024  PRN6     CALL PRINT
     000135  000142
0094 000136  000004           JMP REP
     000137  000044
0095 *
0096 *          SUBROUTINE PRINT
0097 *
0098 000140  000004  NOTLNK   JMP NOTNORM
     000141  000352
0099 000142  000043  PRINT    LDAN H10H
     000143  000020
0100 000144  000072           OUT 2
0101 000145  000017           INX 7
0102 000146  000122           BBS PRN,2
     000147  000151
0103 000150  000203           RET
0104 000151  000277  PRN      MOVN H05H,7
     000152  000005
0105 000153  000376           LDA 6
0106 000154  000323           XORN 6
     000155  000006
0107 000156  000226           BNZ SKIPIOA
     000157  000166
0108 000160  000043  SKIPIO   LDAN H0DH
     000161  000015
0109 000162  000124           CALL PRNT
     000163  000000
0110 000164  000357           DBNZ SKIPIO,7
     000165  000160
0111 000166  000277  SKIPIOA  MOVN 12,7
     000167  000014
0112 000170  000273           MOVN DATMSG-1,3
     000171  001061
0113 000172  000124           CALL MEM
     000173  000052
```

```
0114  000174  000064               CALL CALDAY
      000175  000125
0115  000176  000277               MOVN 9,7
      000177  000011
0116  000200  000273               MOVN TIMMSG-1,3
      000201  001075
0117  000202  000124               CALL MEM
      000203  000052
0118  000204  000277               MOVN 7,7
      000205  000007
0119  000206  000273               MOVN 3,3
      000207  000003
0120  000210  000064               CALL TIME
      000211  000105
0121  000212  000272               MOVN 2,2
      000213  000002
0122  000214  000043  TWICE        LDAN H3AH
      000215  000072
0123  000216  000124               CALL PRNT
      000217  000000
0124  000220  000273               MOVN 2,3
      000221  000002
0125  000222  000064               CALL TIME
      000223  000105
0126  000224  000352               DBNZ TWICE,2
      000225  000214
0127  000226  000277               MOVN 18,7
      000227  000022
0128  000230  000273               MOVN STRMSG-1,3
      000231  001107
0129  000232  000124               CALL MEM
      000233  000052
0130  000234  000375               LDA 5
0131  000235  000123               ANDN H0FH
      000236  000017
0132  000237  000003               ADDN H30H
      000240  000060
0133  000241  000124               CALL PRNT
      000242  000000
0134  000243  000277               MOVN 5,7
      000244  000005
0135  000245  000273               MOVN DBLCRMSG,3
      000246  001132
0136  000247  000124               CALL MEM
      000250  000052
0137  000251  000356               DBNZ NOTPRESS,6
      000252  000257
0138  000253  000273               MOVN PRESMESG-1,3
      000254  001137
0139  000255  000064               CALL ERR
      000256  000041
```

```
0140  000257  000356  NOTPRESS DBNZ NOTT1,6
      000260  000265
0141  000261  000273           MOVN ASTT1MSG-1,3
      000262  001143
0142  000263  000064           CALL ERR
      000264  000041
0143  000265  000356  NOTT1    DBNZ NOTLNK,6
      000256  000140
0144  000267  000277  M3       MOVN 8,7
      000270  000010
0145  000271  000273           MOVN T1-MSG-1,3
      000272  001147
0146  000273  000124           CALL MEM
      000274  000052
0147  000275  000277           MOVN 3,7
      000276  000003
0148  000277  000272           MOVN 3,2
      000300  000003
0149  000301  000271           MOVN T1,1
      000302  000032
0150  000303  000064           CALL DM
      000304  000007
0151  000305  000277           MOVN 14,7
      000306  000016
0152  000307  000273           MOVN SECT2MSG-1,3
      000310  001157
0153  000311  000124           CALL MEM
      000312  000052
0154  000313  000277           MOVN 3,7
      000314  000003
0155  000315  000272           MOVN 3,2
      000316  000003
0156  000317  000271           MOVN T2,1
      000320  000035
0157  000321  000064           CALL DM
      000322  000007
0158  000323  000277           MOVN 21,7
      000324  000025
0159  000325  000273           MOVN SECPFMSG-1,3
      000326  001175
0160  000327  000124           CALL MEM
      000330  000052
0161  000331  000277           MOVN 2,7
      000332  000002
0162  000333  000272           MOVN 2,2
      000334  000002
0163  000335  000271           MOVN PF,1
      000336  000030
0164  000337  000064           CALL DM
      000340  000007
0165  000341  000277           MOVN 2,7
```

```
       000342  000002
0166   000343  000273                   MOVN PRCNTMSG,3
       000344  001222
0167   000345  000124                   CALL MEM
       000345  000052
0168   000347  000203  ABORT            RET
0169   000350  000004  STRCYCL          JMP STRCYC
       000351  000372
0170   000352  000356  NOTNORM          DBNZ NOTT2,6
       000353  000362
0171   000354  000273                   MOVN ASTT2MSG-1,3
       000355  001224
0172   000355  000064                   CALL ERR
       000357  000041
0173   000360  000004                   JMP M3
       000361  000267
0174   000362  000356  NOTT2            DBNZ STRCYCL,6
       000363  000350
0175   000364  000273                   MOVN ASTPFMSG-1,3
       000365  001230
0176   000366  000064                   CALL ERR
       000367  000041
0177   000370  000004                   JMP M3
       000371  000267
0178   000372  000356  STRCYC           DBNZ ABORT,6
       000373  000347
0179   000374  000277                   MOVN 16,7
       000375  000020
0180   000376  000273                   MOVN STRMSCG-1,3
       000377  001324
0181   000400  000124                   CALL MEM
       000401  000052
0182   000402  000004                   JMP ABORT
       000403  000347
0183   *
0184   *             SUBROUTINE DM
0185   *
0186   000404  000000                   NOP
0187   000405  000000                   NOP
0188   000406  000000                   NOP
0189   000407  000361  DM               LDAI 1
0190   000410  000064                   CALL SDM
       000411  000024
0191   000412  000031                   INC 1
0192   000413  000357                   DBNZ MSD,7
       000414  000016
0193   000415  000203                   RET
0194   000416  000361  MSD              LDAI 1
0195   000417  000107                   SWAP
0196   000420  000064                   CALL SDM
       000421  000024
```

```
0197  000422  000044                JMP DM
      000423  000007
0198  *
0199  *       SUBROUTINE SDM
0200  *
0201  000424  000123  SDM           ANDN H0FH
      000425  000017
0202  000426  000003                ADDN H30H
      000427  000060
0203  000430  000124                CALL PRNT
      000431  000000
0204  000432  000352                DBNZ NOPERIOD,2
      000433  000040
0205  000434  000043                LDAN H2EH
      000435  000056
0206  000436  000124                CALL PRNT
      000437  000000
0207  000440  000203  NOPERIOD RET
0208  000441  000064  ERR           CALL ASTR
      000442  000070
0209  000443  000272                MOVN 5,2
      000444  000005
0210  000445  000043  ERRLOOP  LDAN H20H
      000446  000040
0211  000447  000124                CALL PRNT
      000450  000000
0212  000451  000352                DBNZ ERRLOOP,2
      000452  000045
0213  000453  000277                MOVN 4,7
      000454  000004
0214  000455  000124                CALL MEM
      000456  000052
0215  000457  000277                MOVN 7,7
      000460  000007
0216  000461  000273                MOVN ALARMMSG-1,3
      000462  001314
0217  000463  000124                CALL MEM
      000464  000052
0218  000465  000064                CALL ASTR
      000466  000070
0219  000467  000203                RET
0220  *
0221  *        SUBROUTINE ASTR
0222  *
0223  000470  000277  ASTR          MOVN H14H,7
      000471  000024
0224  000472  000043  CONTINUE LDAN H2AH
      000473  000052
0225  000474  000124                CALL PRNT
      000475  000000
0226  000476  000357                DBNZ CONTINUE,7
```

```
      000477  000072
0227  000500  000043           LDAN H0DH
      000501  000015
0228  000502  000124           CALL PRNT
      000503  000000
0229  000504  000203           RET
0230  *
0231  *       SUBROUTINE TIME
0232  *
0233  000505  000043  TIME     LDAN H50H
      000506  000120
0234  000507  000072           OUT 2
0235  000510  000377           LDA 7
0236  000511  000076           OUTX 6
0237  000512  000017           INX 7
0238  000513  000123           ANDN H0FH
      000514  000017
0239  000515  000003           ADDN H30H
      000516  000060
0240  000517  000124           CALL PRNT
      000520  000000
0241  000521  000317           DEC 7
0242  000522  000353           DBNZ TIME,3
      000523  000105
0243  000524  000203           RET
0244  *
0245  *       ROUTINE TO PRINT CALENDAR DAY
0246  *
0247  *       R5 IS SAVED
0248  *       R0= MONTH TABLE POINTER
0249  *       R7= JULIAN DAY COUNTER
0250  *       R6= DIGIT COUNTER
0251  *
0252  000525  000270  CALDAY   MOVN H27H,0   SAVE R5
      000526  000047
0253  000527  000375           LDA 5
0254  000530  000240           STAI 0
0255  000531  000030           INC 0
0256  000532  000376           LDA 6
0257  000533  000240           STAI 0
0258  000534  000270           MOVN MONTBL-1,0 INITIALIZE
      000535  000730
0259  000536  000277           MOVN 1,7
      000537  000001
0260  000540  000043           LDAN 57H      READ 100'S DAYS
      000541  000127
0261  000542  000072           OUT 2
0262  000543  000076           OUTX 6
0263  000544  000017           INX 7
0264  000545  000256           STA 6
0265  000546  000036           INC 6
```

```
0266  000547  000356  CL1     DBNZ CL2,6     CALCULATE MONTH/DAY
      000550  000153
0267  000551  000044          JMP CL3
      000552  000170
0268  000553  000227  CL2     CLC
0269  000554  000307          LDAS
0270  000555  000123          ANDN H3FH
      000556  000077
0271  000557  000327          STAS
0272  000560  000275          MOVN 0,5
      000561  000000
0273  000562  000064  CL2A    CALL CNT
      000563  000345
0274  000564  000366          BCS CL1
      000565  000147
0275  000566  000346          BCC CL2A
      000567  000162
0276  000570  000043  CL3     LDAN 6         READ 10'S DAYS
      000571  000006
0277  000572  000076          OUTX 6
0278  000573  000017          INX 7
0279  000574  000256          STA 6
0280  000575  000036          INC 6
0281  000576  000356  CL4     DBNZ CL5,6     CALCULATE MONTH/DAY
      000577  000202
0282  000600  000044          JMP CL7
      000601  000213
0283  000602  000275  CL5     MOVN 0,5
      000603  000000
0284  000604  000064  CL6     CALL CNT
      000605  000345
0285  000606  000375          LDA 5
0286  000607  000222          BBS CL4,4
      000610  000176
0287  000611  000044          JMP CL6
      000612  000204
0288  000613  000043  CL7     LDAN 5         READ 1'S DAYS
      000614  000005
0289  000615  000076          OUTX 6
0290  000616  000017          INX 7
0291  000617  000256          STA 6
0292  000620  000036          INC 6
0293  000621  000356  CL8     DBNZ CL9,6     CALCULATE MONTH/DAY
      000622  000225
0294  000623  000044          JMP CL10
      000624  000233
0295  000625  000064  CL9     CALL CNT
      000626  000345
0296  000627  000044          JMP CL8
      000630  000221
0297  000631  000044  CNT1LK  JMP CNT1
```

```
        000632  000354
0298    000633  000377  CL10    LDA 7           CALCULATE DAY
0299    000634  000067          CMA
0300    000635  000027          INA
0301    000636  000257          STA 7
0302    000637  000370          LDA 0
0303    000640  000243          LDAA
0304    000641  000157          ADD 7
0305    000642  000257          STA 7
0306    000643  000307          LDAS
0307    000644  000123          ANDN H3FH
        000645  000077
0308    000646  000327          STAS
0309    000647  000377          LDA 7
0310    000650  000222          BBS CL11,4
        000651  000254
0311    000652  000044          JMP CL12
        000653  000257
0312    000654  000127  CL11    DAA
0313    000655  000003          ADDN 6
        000656  000006
0314    000657  000127  CL12    DAA
0315    000660  000256          STA 6
0316    000661  000277          MOVN MONTBL,7
        000662  000731
0317    000663  000377          LDA 7           CALCULATE MONTH POINTER
0318    000664  000067          CMA
0319    000665  000027          INA
0320    000666  000150          ADD 0
0321    000667  000347          RL
0322    000670  000347          RL
0323    000671  000273          MOVN MONLBL,3
        000672  001235
0324    000673  000153          ADD 3
0325    000674  000253          STA 3           PRINT MONTH
0326    000675  000313          DEC 3
0327    000676  000277          MOVN 4,7
        000677  000004
0328    000700  000124          CALL MEM
        000701  000052
0329    000702  000376          LDA 6
0330    000703  000107          SWAP
0331    000704  000123          ANDN H0FH
        000705  000017
0332    000706  000003          ADDN H30H
        000707  000060
0333    000710  000124          CALL PRNT
        000711  000000
0334    000712  000376          LDA 6
0335    000713  000123          ANDN H0FH
        000714  000017
```

```
000715  000003            ADDN H30H
000716  000060
000717  000124            CALL PRNT
000720  000000
000721  000270            MOVN H27H,0
000722  000047
000723  000360            LDAI 0
000724  000255            STA 5
000725  000030            INC 0
000726  000360            LDAI 0
000727  000256            STA 6
000730  000203            RET
*
*       TABLE
*
000731  000040  MONTBL    OCT 40          JAN
000732  000035            OCT 35          FEB
000733  000040            OCT 40          MAR
000734  000037            OCT 37          APR
000735  000040            OCT 40          MAY
000736  000037            OCT 37          JUN
000737  000040            OCT 40          JUL
000740  000040            OCT 40          AUG
000741  000037            OCT 37          SEP
000742  000040            OCT 40          OCT
000743  000037            OCT 37          NOV
000744  000040            OCT 40          DEC
*
*       SUBROUTINE "CNT"
*
000745  000357  CNT       DBNZ CNT1,7
000746  000354
000747  000030            INC 0
000750  000370            LDA 0
000751  000243            LDAA
000752  000007            DCA
000753  000257            STA 7
000754  000375  CNT1      LDA 5
000755  000003            ADDN 1
000756  000001
000757  000127            DAA
000760  000255            STA 5
000761  000203            RET
001000                    ORG 1000B
*
*        MEM MUST BE ON THE
*        SAME PAGE AS ASCII TABLES
*
*
*        SUBROUTINE PRNT
*
```

```
0382  001000  000205  PRNT      CLF0
0383  001001  000254            STA 4
0384  001002  000323            XORN 15B
      001003  000015
0385  001004  000226            BNZ SETFLAG
      001005  000007
0386  001006  000225            CMF0
0387  001007  000043  SETFLAG   LDAN H11H
      001010  000021
0388  001011  000072            OUT 2
0389  001012  000076            OUTX 6
0390  001013  000374            LDA 4
0391  001014  000074            OUTX 4
0392  001015  000107            SWAP
0393  001016  000075            OUTX 5
0394  001017  000047            CLA
0395  001020  000076            OUTX 6
0396  001021  000274            MOVN H3CH,4
      001022  000074
0397  001023  000017  MICRO300  INX 7
0398  001024  000067            CMA
0399  001025  000022            BBS DONE,0
      001026  000031
0400  001027  000354            DBNZ MICRO300,4
      001030  000023
0401  001031  000043  DONE      LDAN 1
      001032  000001
0402  001033  000076            OUTX 6
0403  001034  000266            BF0 CR
      001035  000037
0404  001036  000203            RET
0405  001037  000274  CR        MOVN H0FFH,4
      001040  000377
0406  001041  000043  STALL     LDAN H0FFH
      001042  000377
0407  001043  000007  MS650     DCA
0408  001044  000000            NOP
0409  001045  000226            BNZ MS650
      001046  000043
0410  001047  000354            DBNZ STALL,4
      001050  000041
0411  001051  000203            RET
0412  *
0413  *           SUBROUTINE MEM
0414  *
0415  001052  000033  MEM       INC 3
0416  001053  000373            LDA 3
0417  001054  000243            LDAA
0418  001055  000124            CALL PRNT
      001056  000000
0419  001057  000357            DBNZ MEM,7
```

```
      001060  000052
0420  001061  000203            RET
0421  *
0422  *       TABLE
0423  *
0424  001062  000015  DATMSG    ASC \<  DATE     \
      001063  000040
      001064  000040
      001065  000104
      001066  000101
      001067  000124
      001070  000105
      001071  000040
      001072  000040
      001073  000040
      001074  000040
      001075  000040
0425  001076  000000  TIMMSG    ASC \@<  TIME  \
      001077  000015
      001100  000040
      001101  000040
      001102  000124
      001103  000111
      001104  000115
      001105  000105
      001106  000040
      001107  000040
0426  001110  000040  STRMSG    ASC \  <    STREAM NO. \
      001111  000040
      001112  000015
      001113  000040
      001114  000040
      001115  000040
      001116  000040
      001117  000123
      001120  000124
      001121  000122
      001122  000105
      001123  000101
      001124  000115
      001125  000040
      001126  000116
      001127  000117
      001130  000056
      001131  000040
0427  001132  000040  DBLCRMSG ASC \    <<\
      001133  000040
      001134  000040
      001135  000040
      001136  000015
      001137  000015
```

```
0428  001140  000120  PRESMESG ASC \PRES\
      001141  000122
      001142  000105
      001143  000123
0429  001144  000040  ASTT1MSG ASC \ T1 \
      001145  000124
      001146  000061
      001147  000040
0430  001150  000015  T1=MSG   ASC \<  T1 = \
      001151  000040
      001152  000040
      001153  000124
      001154  000061
      001155  000040
      001156  000075
      001157  000040
0431  001160  000040  SECT2MSG ASC \ SEC  <  T2 = \
      001161  000123
      001162  000105
      001163  000103
      001164  000040
      001165  000040
      001166  000015
      001167  000040
      001170  000040
      001171  000124
      001172  000062
      001173  000040
      001174  000075
      001175  000040
0432  001176  000040  SECPFMSG ASC \ SEC  <PLUG FACTOR =\
      001177  000123
      001200  000105
      001201  000103
      001202  000040
      001203  000040
      001204  000015
      001205  000120
      001206  000114
      001207  000125
      001210  000107
      001211  000040
      001212  000106
      001213  000101
      001214  000103
      001215  000124
      001216  000117
      001217  000122
      001220  000040
      001221  000075
0433  001222  000040  PRCNTMSG OCT 40
```

```
0434  001223  000045                    OCT 45          (PERCENT SIGN)
0435  001224  000015                    OCT 15
0436  001225  000040  ASTT2MSG ASC \ T2 \
      001226  000124
      001227  000062
      001230  000040
0437  001231  000040  ASTPFMSG ASC \ PF \
      001232  000120
      001233  000106
      001234  000040
0438  001235  000112  MONLBL   ASC \JAN \
      001236  000101
      001237  000116
      001240  000040
0439  001241  000106           ASC \FEB \
      001242  000105
      001243  000102
      001244  000040
0440  001245  000115           ASC \MAR \
      001246  000101
      001247  000122
      001250  000040
0441  001251  000101           ASC \APR \
      001252  000120
      001253  000122
      001254  000040
0442  001255  000115           ASC \MAY \
      001256  000101
      001257  000131
      001260  000040
0443  001261  000112           ASC \JUN \
      001262  000125
      001263  000116
      001264  000040
0444  001265  000112           ASC \JUL \
      001266  000125
      001267  000114
      001270  000040
0445  001271  000101           ASC \AUG \
      001272  000125
      001273  000107
      001274  000040
0446  001275  000123           ASC \SEP \
      001276  000105
      001277  000120
      001300  000040
0447  001301  000117           ASC \OCT \
      001302  000103
      001303  000124
      001304  000040
0448  001305  000116           ASC \NOV \
     001306  000117
     001307  000126
     001310  000040
0449 001311  000104           ASC \DEC \
     001312  000105
     001313  000103
     001314  000040
0450 001315  000040  ALARMMSG ASC \ ALARM<\
     001316  000101
     001317  000114
     001320  000101
     001321  000122
     001322  000115
     001323  000015
0451 001324  000040  STRMSCG  ASC \  START OF CYCLE<\
     001325  000040
     001326  000123
     001327  000124
     001330  000101
     001331  000122
     001332  000124
     001333  000040
     001334  000117
     001335  000106
     001336  000040
     001337  000103
     001340  000131
     001341  000103
     001342  000114
     001343  000105
     001344  000015
0452 *
0453 *
0454 *
0455 *        DATA
0456 *
0457 *
0458 *
0459 *        VARIABLES
0460 *
0461         000032  T1       EQU 32B
0462         000035  T2       EQU 35B
0463         000030  PF       EQU 30B
0464 *
0465 *        HEX CONSTANT DEFINITION
0466 *
0467         000005  H05H     EQU 5B
0468         000012  H0AH     EQU 12B
0469         000013  H0BH     EQU 13B
0470         000014  H0CH     EQU 14B
0471         000015  H0DH     EQU 15B
```

```
        000016  H0EH     EQU 16B
        000017  H0FH     EQU 17B
        000020  H10H     EQU 20B
        000021  H11H     EQU 21B
        000022  H12H     EQU 22B
        000024  H14H     EQU 24B
        000025  H15H     EQU 25B
        000030  H18H     EQU 30B
        000040  H20H     EQU 40B
        000041  H21H     EQU 41B
        000042  H22H     EQU 42B
        000043  H23H     EQU 43B
        000045  H25H     EQU 45B
        000047  H27H     EQU 47B
        000050  H28H     EQU 50B
        000052  H2AH     EQU 52B
        000056  H2EH     EQU 56B
        000060  H30H     EQU 60B
        000072  H3AH     EQU 72B
        000074  H3CH     EQU 74B
        000077  H3FH     EQU 77B
        000100  H40H     EQU 100B
        000110  H48H     EQU 110B
        000120  H50H     EQU 120B
        000122  H52H     EQU 122B
        000124  H54H     EQU 124B
        000130  H58H     EQU 130B
        000131  H59H     EQU 131B
        000140  H60H     EQU 140B
        000203  H83H     EQU 203B
        000213  H8BH     EQU 213B
        000231  H99H     EQU 231B
        000357  H0EFH    EQU 357B
        000360  H0F0H    EQU 360B
        000377  H0FFH    EQU 377B
  *
  *
  *        END
  *
  *
```

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APPENDIX F

MAINTENANCE LISTINGS

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```
*********************
*********************
*
*
*          PLUGGING FACTOR MONITOR
*          MAINTENANCE SOFTWARE
*
*
*********************.
*********************
*
*          POWER-UP VECTOR
*
                                 ORG 0B
                 0000  RESET     NOP
        0001     0004            JMP MINIT
        0002     001C
*
*          EXTERNAL INTERRUPT VECTOR
*
        0003     0000  EXTINT    NOP
        0004     0000            NOP
        0005     0004            JMP *
        0006     0005
*
*          TIMER/COUNTER INTERRUPT
*
*          INCREMENTS A TIMER IN REGISTER 2,3,4
*          (2 IS LSW, 4 IS MSW)(BANK 0)
*          INCREMENTS EVERY 20MSEC
*
        0007     0035  T/CINT    DITC
        0008     00C5            SR0
        0009     00A9            STA 1
        000A     0097            CLC
        000B     0023            LDAN 2
        000C     0002
        000D     006A            ADD 2
        000E     0057            DAA
        000F     00AA            STA 2
        0010     00E6            BCC RETURN
        0011     0019
        0012     0027            CLA
        0013     007B            ADC 3
        0014     0057            DAA
        0015     00AB            STA 3
        0016     00E6            BCC RETURN
        0017     0019
        0018     001C            INC 4
        0019     00F9  RETURN    LDA 1
        001A     0025            ENTC
```

```
0047     001B   0093          RETR
0048  *
0049  *         MAIN PROGRAM
0050  *
0051     001C   0023   MINIT  LDAN 20H
         001D   0020
0052     001E   003A          OUT 2
0053     001F   003C          OUTX 4
0054     0020   003D          OUTX 5
0055     0021   0023          LDAN 14H
         0022   0014
0056     0023   009E          ANDX 6
0057     0024   0023          LDAN 30H
         0025   0030
0058     0026   003A          OUT 2
0059     0027   003C          OUTX 4
0060     0028   0023          LDAN 47H
         0029   0047
0061     002A   003A          OUT 2
0062     002B   009E          ANDX 6
0063     002C   0004          JMP MAINT
         002D   002E
0064     002E   0023   MAINT  LDAN 30H
         002F   0030
0065     0030   003A          OUT 2
0066     0031   000F          INX 7
0067     0032   00AE          STA 6
0068     0033   0023          LDAN 40H
         0034   0040
0069     0035   003A          OUT 2
0070     0036   000F          INX 7
0071     0037   0053          ANDN 3H
         0038   0003
0072     0039   0047          SWAP
0073     003A   004E          IOR 6
0074     003B   00AE          STA 6
0075     003C   0003          ADDN 336B
         003D   000E
0076     003E   00F7          RLC
0077     003F   00F6          BCS MAIN1
         0040   0043
0078     0041   0027          CLA
0079     0042   00AE          STA 6
0080     0043   00FE   MAIN1  LDA 6
0081     0044   0003          ADDN JTABLE
         0045   0047
0082     0046   00B3          JMPA
0083  *
0084  *         JUMP TABLE
0085  *
0086     0047   0069   JTABLE DEF NONE       R6=0
```

```
0087    0048    0076            DEF LEDJ        1
0088    0049    0076            DEF LEDJ        2
0089    004A    0078            DEF PRINTERJ    3
0090    004B    0076            DEF LEDJ        4
0091    004C    007A            DEF ALARMJ      5
0092    004D    007C            DEF DISPLAYJ 6
0093    004E    007E            DEF TSTTMBJ     7
0094    004F    0076            DEF LEDJ        8   10B
0095    0050    0080            DEF CLOCKJ      9   11B
0096    0051    0082            DEF ADTESTJ     10  12B
0097    0052    0084            DEF SENSORJ     11  13B
0098    0053    008E            DEF D/A1        12  14B
0099    0054    0093            DEF D/A2        13  15B
0100    0055    0098            DEF D/A3        14  16B
0101    0056    009D            DEF D/A4        15  17B
0102    0057    0076            DEF LEDJ        16  20B
0103    0058    00A2            DEF D/A5        17  21B
0104    0059    00A7            DEF D/A6        18  22B
0105    005A    00AC            DEF RELAY1      19  23B
0106    005B    00B1            DEF RELAY2      20  24B
0107    005C    00B6            DEF RELAY3      21  25B
0108    005D    00BB            DEF RELAY4      22  26B
0109    005E    00C0            DEF RELAY5      23  27B
0110    005F    00C5            DEF RELAY6      24  30B
0111    0060    00CA            DEF RELAY7      25  31B
0112    0061    00CF            DEF RELAY8      26  32B
0113    0062    00D4            DEF RELAY9      27  33B
0114    0063    00F0            DEF RELAY10     28  34B
0115    0064    0086            DEF RELAY11J    29  35B
0116    0065    0088            DEF RELAY12J    30  36B
0117    0066    008A            DEF RELAY13J    31  37B
0118    0067    0076            DEF LEDJ        32  40B
0119    0068    008C            DEF RELAY14J    33  41B
0120  *
0121  *         NO OPERATION
0122  *
0123    0069    0023  NONE      LDAN 32
        006A    0020
0124    006B    003A            OUT 2
0125    006C    0009            IN 1
0126    006D    0047            SWAP
0127    006E    0037            CMA
0128    006F    0053            ANDN 7
        0070    0007
0129    0071    0097            CLC
0130    0072    00E7            RL
0131    0073    003E            OUTX 6
0132    0074    0004            JMP MAINT
        0075    002E
0133  *
0134  *         JUMP LINKS
```

```
0135  *
0136     0076    0024  LEDJ      JMP LED
         0077    0079
0137     0078    0024  PRINTERJ  JMP PRINTER
         0079    0094
0138     007A    0024  ALARMJ    JMP ALARM
         007B    00B5
0139     007C    0024  DISPLAYJ  JMP DISPLAY
         007D    00CE
0140     007E    0024  TSTTMBJ   JMP TSTTMB
         007F    00E8
0141     0080    0044  CLOCKJ    JMP CLOCK
         0081    000F
0142     0082    0044  ADTESTJ   JMP ADTEST
         0083    0041
0143     0084    0044  SENSORJ   JMP SENSOR
         0085    007A
0144     0086    0024  RELAY11J  JMP RELAY11
         0087    000C
0145     0088    0024  RELAY12J  JMP RELAY12
         0089    0011
0146     008A    0024  RELAY13J  JMP RELAY13
         008B    0016
0147     008C    0024  RELAY14J  JMP RELAY14
         008D    001B
0148  *
0149  *             D TO A TESTS
0150  *
0151     008E    0023  D/A1      LDAN 1H
         008F    0001
0152     0090    00AD            STA 5
0153     0091    0024            JMP DATST
         0092    0072
0154  *
0155     0093    0023  D/A2      LDAN 2H
         0094    0002
0156     0095    00AD            STA 5
0157     0096    0024            JMP DATST
         0097    0072
0158  *
0159     0098    0023  D/A3      LDAN 3H
         0099    0003
0160     009A    00AD            STA 5
0161     009B    0024            JMP DATST
         009C    0072
0162  *
0163     009D    0023  D/A4      LDAN 4H
         009E    0004
0164     009F    00AD            STA 5
0165     00A0    0024            JMP DATST
         00A1    0072
```

```
0166  *
0167     00A2    0023  D/A5     LOAN 5H
         00A3    0005
0168     00A4    00AD           STA 5
0169     00A5    0024           JMP DATST
         00A6    0072
0170  *
0171     00A7    0023  D/A6     LOAN 6H
         00A8    0006
0172     00A9    00AD           STA 5
0173     00AA    0024           JMP DATST
         00AB    0072
0174  *
0175  *        RELAY TESTS
0176  *
0177     00AC    0023  RELAY1   LOAN 1
         00AD    0001
0178     00AE    00AE           STA 6
0179     00AF    0024           JMP RLYP4
         00B0    0020
0180  *
0181     00B1    0023  RELAY2   LOAN 2
         00B2    0002
0182     00B3    00AE           STA 6
0183     00B4    0024           JMP RLYP4
         00B5    0020
0184  *
0185     00B6    0023  RELAY3   LOAN 4
         00B7    0004
0186     00B8    00AE           STA 6
0187     00B9    0024           JMP RLYP4
         00BA    0020
0188  *
0189     00BB    0023  RELAY4   LOAN 8
         00BC    0008
0190     00BD    00AE           STA 6
0191     00BE    0024           JMP RLYP4
         00BF    0020
0192  *
0193     00C0    0023  RELAY5   LOAN 1
         00C1    0001
0194     00C2    00AE           STA 6
0195     00C3    0024           JMP RLYP5
         00C4    003C
0196  *
0197     00C5    0023  RELAY6   LOAN 2
         00C6    0002
0198     00C7    00AE           STA 6
0199     00C8    0024           JMP RLYP5
         00C9    003C
0200  *
```

```
0201     00CA     0023   RELAY7    LDAN 4
         00CB     0004
0202     00CC     00AE             STA 6
0203     00CD     0024             JMP RLYP5
         00CE     003C
0204  *
0205     00CF     0023   RELAY8    LDAN 8
         00D0     0008
0206     00D1     00AE             STA 6
0207     00D2     0024             JMP RLYP5
         00D3     003C
0208  *
0209     00D4     0023   RELAY9    LDAN 24H
         00D5     0024
0210     00D6     003A             OUT 2
0211     00D7     003F             OUTX 7
0212     00D8     0027             CLA
0213     00D9     003F             OUTX 7
0214     00DA     0023             LDAN 40H
         00DB     0040
0215     00DC     003A             OUT 2
0216     00DD     000F             INX 7
0217     00DE     0052             BBS RLY9A,2
         00DF     00E8
0218     00E0     0023             LDAN 20H
         00E1     0020
0219     00E2     003A             OUT 2
0220     00E3     0023             LDAN 1
         00E4     0001
0221     00E5     008E             IORX 6
0222     00E6     0004             JMP MAINT
         00E7     002E
0223     00E8     0023   RLY9A     LDAN 20H
         00E9     0020
0224     00EA     003A             OUT 2
0225     00EB     0023             LDAN 14
         00EC     000E
0226     00ED     009E             ANDX 6
0227     00EE     0004             JMP MAINT
         00EF     002E
0228  *
0229     00F0     0023   RELAY10   LDAN 24H
         00F1     0024
0230     00F2     003A             OUT 2
0231     00F3     003F             OUTX 7
0232     00F4     0027             CLA
0233     00F5     003F             OUTX 7
0234     00F6     0023             LDAN 40H
         00F7     0040
0235     00F8     003A             OUT 2
0236     00F9     000F             INX 7
```

```
0237     00FA     0000                NOP
0238     00FB     0000                NOP
0239     00FC     0000                NOP
0240     00FD     0000                NOP
0241     00FE     0000                NOP
0242     00FF     0000                NOP
0243     0100     0000                NOP
0244     0101     0052                BBS RLY10A,2
         0102     0008
0245     0103     0023                LDAN 8
         0104     0008
0246     0105     003E                OUTX 6
0247     0106     0004                JMP MAINT
         0107     002E
0248     0108     0027    RLY10A      CLA
0249     0109     003E                OUTX 6
0250     010A     0004                JMP MAINT
         010B     002E
0251   *
0252     010C     0023    RELAY11     LDAN 1
         010D     0001
0253     010E     00AE                STA 6
0254     010F     0024                JMP RLYP4A
         0110     0058
0255   *
0256     0111     0023    RELAY12     LDAN 2
         0112     0002
0257     0113     00AE                STA 6
0258     0114     0024                JMP RLYP4A
         0115     0058
0259   *
0260     0116     0023    RELAY13     LDAN 4
         0117     0004
0261     0118     00AE                STA 6
0262     0119     0024                JMP RLYP4A
         011A     0058
0263   *
0264     011B     0023    RELAY14     LDAN 8
         011C     0008
0265     011D     00AE                STA 6
0266     011E     0024                JMP RLYP4A
         011F     0058
0267   *
0268   *
0269     0120     0023    RLYP4       LDAN 24H
         0121     0024
0270     0122     003A                OUT 2
0271     0123     003F                OUTX 7
0272     0124     0027                CLA
0273     0125     003F                OUTX 7
0274     0126     0023                LDAN 40H
```

```
        0127    0040
0275    0128    003A                OUT 2
0276    0129    000F                INX 7
0277    012A    0052                BBS RLYA,2
        012B    0033
0278    012C    0023                LDAN 20H
        012D    0020
0279    012E    003A                OUT 2
0280    012F    00FE                LDA 6
0281    0130    003C                OUTX 4
0282    0131    0004                JMP MAINT
        0132    002E
0283    0133    0023    RLYA        LDAN 20H
        0134    0020
0284    0135    003A                OUT 2
0285    0136    0027                CLA
0286    0137    003C                OUTX 4
0287    0138    0004                JMP MAINT
        0139    002E
0288  *
0289  *
0290    013A    0024    RLYE        JMP RLYB
        013B    004F
0291    013C    0023    RLYP5       LDAN 24H
        013D    0024
0292    013E    003A                OUT 2
0293    013F    003F                OUTX 7
0294    0140    0027                CLA
0295    0141    003F                OUTX 7
0296    0142    0023                LDAN 40H
        0143    0040
0297    0144    003A                OUT 2
0298    0145    000F                INX 7
0299    0146    0052                BBS RLYE,2
        0147    003A
0300    0148    0023                LDAN 20H
        0149    0020
0301    014A    003A                OUT 2
0302    014B    00FE                LDA 6
0303    014C    003D                OUTX 5
0304    014D    0004                JMP MAINT
        014E    002E
0305    014F    0023    RLYB        LDAN 20H
        0150    0020
0306    0151    003A                OUT 2
0307    0152    0027                CLA
0308    0153    003D                OUTX 5
0309    0154    0004                JMP MAINT
        0155    002E
0310  *
0311  *
```

```
0312    0156    0024  RLYD     JMP RLYC
        0157    006B
0313    0158    0023  RLYP4A   LDAN 24H
        0159    0024
0314    015A    003A           OUT 2
0315    015B    003F           OUTX 7
0316    015C    0027           CLA
0317    015D    003F           OUTX 7
0318    015E    0023           LDAN 40H
        015F    0040
0319    0160    003A           OUT 2
0320    0161    000F           INX 7
0321    0162    0052           BBS RLYD,2
        0163    0056
0322    0164    0023           LDAN 30H
        0165    0030
0323    0166    003A           OUT 2
0324    0167    00FE           LDA 6
0325    0168    003C           OUTX 4
0326    0169    0004           JMP MAINT
        016A    002E
0327    016B    0023  RLYC     LDAN 30H
        016C    0030
0328    016D    003A           OUT 2
0329    016E    0027           CLA
0330    016F    003C           OUTX 4
0331    0170    0004           JMP MAINT
        0171    002E
0332  *
0333  *         MAIN D/A TEST
0334  *
0335    0172    0023  DATST    LDAN 3
        0173    0003
0336    0174    00AF           STA 7
0337    0175    0054           CALL THUMB
        0176    0003
0338    0177    0004           JMP MAINT
        0178    002E
0339  *
0340  *         STREAM LED TESTS
0341  *
0342    0179    0027  LED      CLA
0343    017A    00AD           STA 5
0344    017B    0097           CLC
0345    017C    00FE           LDA 6
0346    017D    001D  LD1      INC 5
0347    017E    0067           RRC
0348    017F    00E6           BCC LD1
        0180    007D
0349    0181    00FD           LDA 5
0350    0182    0043           IORN F0H
```

```
        0183     00F0
0351    0184     0039               OUT 1
0352    0185     0023               LDAN 88
        0186     0058
0353    0187     003A               OUT 2
0354    0188     003E               OUTX 6
0355    0189     0027               CLA
0356    018A     003E               OUTX 6
0357    018B     0023               LDAN 20H
        018C     0020
0358    018D     003A               OUT 2
0359    018E     00FD               LDA 5
0360    018F     0097               CLC
0361    0190     00E7               RL
0362    0191     003E               OUTX 6
0363    0192     0004               JMP MAINT
        0193     002E
0364  *
0365  *             PRINTER TEST
0366  *
0367    0194     0023   PRINTER     LDAN 20H
        0195     0020
0368    0196     00AB               STA 3
0369    0197     0023               LDAN 19
        0198     0013
0370    0199     00AD               STA 5
0371    019A     00FB   PRT1        LDA 3
0372    019B     0054               CALL PRNT
        019C     0099
0373    019D     00ED               DBNZ PRT2,5
        019E     00A6
0374    019F     0023               LDAN 15B
        01A0     000D
0375    01A1     0054               CALL PRNT
        01A2     0099
0376    01A3     0023               LDAN 19
        01A4     0013
0377    01A5     00AD               STA 5
0378    01A6     001B   PRT2        INC 3
0379    01A7     00FB               LDA 3
0380    01A8     00D3               XORN 123
        01A9     007B
0381    01AA     0096               BNZ PRT1
        01AB     009A
0382    01AC     0023               LDAN 15B
        01AD     000D
0383    01AE     0054               CALL PRNT
        01AF     0099
0384    01B0     0027               CLA
0385    01B1     0054               CALL PRNT
        01B2     0099
```

```
0386     01B3     0004               JMP MAINT
         01B4     002E
0387  *
0388  *           ALARM TEST
0389  *
0390     01B5     0023     ALARM     LDAN 31
         01B6     001F
0391     01B7     003A               OUT 2
0392     01B8     003E               OUTX 6
0393     01B9     0023               LDAN 1
         01BA     0001
0394     01BB     003E               OUTX 6
0395     01BC     0023               LDAN 27H
         01BD     0027
0396     01BE     003A               OUT 2
0397     01BF     003F               OUTX 7
0398     01C0     0027               CLA
0399     01C1     003F               OUTX 7
0400     01C2     0023     ALM1      LDAN 40H
         01C3     0040
0401     01C4     003A               OUT 2
0402     01C5     000F               INX 7
0403     01C6     0052               BBS ALM1,2
         01C7     00C2
0404     01C8     00BF               MOVN 1,7
         01C9     0001
0405     01CA     0054               CALL DELAY
         01CB     00C3
0406     01CC     0004               JMP MAINT
         01CD     002E
0407  *
0408  *           DISPLAY TEST
0409  *
0410     01CE     00BD     DISPLAY   MOVN 6,5
         01CF     0006
0411     01D0     00BE     DISP2     MOVN 0,6
         01D1     0000
0412     01D2     00B8     DISP1     MOVN PF,0
         01D3     0018
0413     01D4     00FE               LDA 6
0414     01D5     00A0               STAI 0
0415     01D6     0018               INC 0
0416     01D7     00A0               STAI 0
0417     01D8     0054               CALL LATCH12
         01D9     00D1
0418     01DA     00BF               MOVN 1,7
         01DB     0001
0419     01DC     0054               CALL DELAY
         01DD     00C3
0420     01DE     00FE               LDA 6
0421     01DF     0017               INA
```

```
      01E0   0047            SWAP
      01E1   0017            INA
      01E2   00AE            STA 6
      01E3   00D3            XORN AAH
      01E4   00AA
      01E5   0096            BNZ DISP1
      01E6   00D2
      01E7   00ED            DBNZ DISP2,5
      01E8   00D0
      01E9   0004            JMP MAINT
      01EA   002E
*
*            TEST THUMBDIALS
*            OUTPUT TO DISPLAY
*
      01EB   00BF   TSTTMB   MOVN 1,7
      01EC   0001
      01ED   00BD            MOVN 1,5
      01EE   0001
      01EF   0085            CLF0
      01F0   0095            CMF0
      01F1   0054            CALL THUMB
      01F2   0003
      01F3   001D            INC 5
      01F4   0085            CLF0
      01F5   0054            CALL THUMB
      01F6   0003
      01F7   001D            INC 5
      01F8   008F            MOVN 6,7
      01F9   0006
      01FA   0095            CMF0
      01FB   0054            CALL THUMB
      01FC   0003
      01FD   001D            INC 5
      01FE   0085            CLF0
      01FF   0054            CALL THUMB
      0200   0003
      0201   0004            JMP MAINT
      0202   002E
*
*            THUMB ROUTINE(READ THUMBDIAL AND
*            OUTPUT TO DISPLAY
*            R5=STREAM SELECT
*            R7=DIGIT WHERE THUMBDIAL READ STARTS
*
      0203   0054   THUMB    CALL THUMBDIL
      0204   00FE
      0205   00B9            MOVN PF,1
      0206   0018
      0207   00FE            LDA 6
      0208   00A1            STAI 1
```

```
0459     0209    0019                 INC 1
0460     020A    00F8                 LDA 0
0461     020B    00A1                 STAI 1
0462     020C    0054                 CALL LATCH12
         020D    00D1
0463     020E    0093                 RETR
0464  *
0465  *          CLOCK TEST
0466  *
0467     020F    00BF   CLOCK         MOVN 1,7
         0210    0001
0468     0211    00BD                 MOVN 1,5
         0212    0001
0469     0213    0085                 CLF0
0470     0214    0054                 CALL CLKRD
         0215    0025
0471     0216    00BF                 MOVN 3,7
         0217    0003
0472     0218    00BD                 MOVN 2,5
         0219    0002
0473     021A    0054                 CALL CLKRD
         021B    0025
0474     021C    00BF                 MOVN 5,7
         021D    0005
0475     021E    00BD                 MOVN 3,5
         021F    0003
0476     0220    0095                 CMF0
0477     0221    0054                 CALL CLKRD
         0222    0025
0478     0223    0004                 JMP MAINT
         0224    002E
0479  *
0480  *          CLOCK READ ROUTINE
0481  *
0482     0225    0023   CLKRD         LDAN 50H
         0226    0050
0483     0227    003A                 OUT 2
0484     0228    00FF                 LDA 7
0485     0229    003E                 OUTX 6
0486     022A    000F                 INX 7
0487     022B    00B9                 MOVN PF+1,1
         022C    0019
0488     022D    00A1                 STAI 1
0489     022E    001F                 INC 7
0490     022F    00FF                 LDA 7
0491     0230    003E                 OUTX 6
0492     0231    000F                 INX 7
0493     0232    0047                 SWAP
0494     0233    0041                 IORI 1
0495     0234    00A1                 STAI 1
0496     0235    001F                 INC 7
```

```
0497    0236    00FF                LDA 7
0498    0237    003E                OUTX 6
0499    0238    000F                INX 7
0500    0239    00B6                BF0 CLKR1
        023A    003C
0501    023B    0027                CLA
0502    023C    00C9    CLKR1       DEC 1
0503    023D    00A1                STAI 1
0504    023E    0054                CALL LATCH12
        023F    00D1
0505    0240    0093                RETR
0506 *
0507 *                A TO D TEST
0508 *
0509    0241    00BF    ADTEST      MOVN 3,7
        0242    0003
0510    0243    00BD                MOVN 1,5
        0244    0001
0511    0245    0054                CALL THUMB
        0246    0003
0512    0247    0023                LDAN 24
        0248    0018
0513    0249    003A                OUT 2
0514    024A    003D                OUTX 5
0515.   024B    0027                CLA
0516    024C    003D                OUTX 5
0517    024D    0023                LDAN 40H
        024E    0040
0518    024F    003A                OUT 2
0519    0250    000F                INX 7
0520    0251    0072                BBS *,3
        0252    0051
0521    0253    0023                LDAN 30H
        0254    0030
0522    0255    003A                OUT 2
0523    0256    000E                INX 6
0524    0257    0037                CMA
0525    0258    0053                ANDN 14B
        0259    000C
0526    025A    0077                RR
0527    025B    0077                RR
0528    025C    00BD                MOVN 2,5
        025D    0002
0529    025E    00B9                MOVN PF,1
        025F    0018
0530    0260    00A1                STAI 1
0531    0261    0019                INC 1
0532    0262    000E                INX 6
0533    0263    0037                CMA
0534    0264    0053                ANDN 3B
        0265    0003
```

```
0535   0266   0047             SWAP
0536   0267   00E7             RL
0537   0268   00A1             STAI 1
0538   0269   000D             INX 5
0539   026A   0037             CMA
0540   026B   0053             ANDN 8
       026C   0008
0541   026D   00E7             RL
0542   026E   0041             IORI 1
0543   026F   00A1             STAI 1
0544   0270   000D             INX 5
0545   0271   0037             CMA
0546   0272   0053             ANDN 7B
       0273   0007
0547   0274   0041             IORI 1
0548   0275   00A1             STAI 1
0549   0276   0054             CALL LATCH12
       0277   00D1
0550   0278   0004             JMP MAINT
       0279   002E
0551   *
0552   *             SENSOR TESTS
0553   *
0554   027A   0086   SENSOR    BIL S1
       027B   007E
0555   027C   0044             JMP S2
       027D   008A
0556   027E   0023   S1        LDAN 22H
       027F   0022
0557   0280   003A             OUT 2
0558   0281   003E             OUTX 6
0559   0282   008F             MOVN 1,7
       0283   0001
0560   0284   0054             CALL DELAY
       0285   00C3
0561   0286   0023             LDAN 20H
       0287   0020
0562   0288   003A             OUT 2
0563   0289   003E             OUTX 6
0564   028A   0023   S2        LDAN 10H
       028B   0010
0565   028C   003A             OUT 2
0566   028D   000F             INX 7
0567   028E   0053             ANDN 2
       028F   0002
0568   0290   00E7             RL
0569   0291   00AF             STA 7
0570   0292   0023             LDAN 20H
       0293   0020
0571   0294   003A             OUT 2
0572   0295   00FF             LDA 7
```

```
0573    0296    003E              OUTX 6
0574    0297    0004              JMP MAINT
        0298    002E
0575  ***************
0576  *
0577  *           ROUTINES FROM PLUG FACTOR
0578  *           SOFTWARE
0579  *
0580  ***************
0581  *
0582  *           SUBROUTINE PRNT
0583  *
0584    0299    0085    PRNT      CLF0
0585    029A    00AC              STA 4
0586    029B    0003              XORN 15B
        029C    000D
0587    029D    0096              BNZ SETFLAG
        029E    00A0
0588    029F    0095              CMF0
0589    02A0    0023    SETFLAG   LDAN 11H
        02A1    0011
0590    02A2    003A              OUT 2
0591    02A3    003E              OUTX 6
0592    02A4    00FC              LDA 4
0593    02A5    003C              OUTX 4
0594    02A6    0047              SWAP
0595    02A7    003D              OUTX 5
0596    02A8    0027              CLA
0597    02A9    003E              OUTX 6
0598    02AA    00BC              MOVN 3CH,4
        02AB    003C
0599    02AC    000F    MICRO300  INX 7
0600    02AD    0037              CMA
0601    02AE    0012              BBS DONE,0
        02AF    00B2
0602    02B0    00EC              DBNZ MICRO300,4
        02B1    00AC
0603    02B2    0023    DONE      LDAN 1
        02B3    0001
0604    02B4    003E              OUTX 6
0605    02B5    0086              BF0 CR
        02B6    00B8
0606    02B7    0083              RET
0607    02B8    00BC    CR        MOVN FFH,4
        02B9    00FF
0608    02BA    0023    STALL     LDAN FFH
        02BB    00FF
0609    02BC    0007    MS650     DCA
0610    02BD    0000              NOP
0611    02BE    0096              BNZ MS650
        02BF    00BC
```

```
0612      02C0     00EC             DBNZ STALL,4
          02C1     008A
0613      02C2     0083             RET
0614  *
0615  *         SUBROUTINE DELAY
0616  *
0617  *         DELAYS NO OF SECONDS IN R7
0618  *
0619      02C3     0027  DELAY      CLA
0620      02C4     00AA             STA 2
0621      02C5     00AB             STA 3
0622      02C6     00AC             STA 4
0623      02C7     0062             STAT
0624      02C8     0055             TIME
0625      02C9     0025             ENTC
0626      02CA     00FB  LOOP0      LDA 3
0627      02CB     00DF             XOR 7
0628      02CC     0096             BNZ LOOP0
          02CD     00CA
0629      02CE     0035             DITC
0630      02CF     0065             STOP
0631      02D0     0093             RETR
0632  *
0633  *         SUBROUTINE 12-BIT LATCH
0634  *
0635  *         OUTPUTS DATA LOCATED IN LOCATIONS
0636  *         24 AND 25 TO 12-BIT LATCHES
0637  *
0638      02D1     0023  LATCH12    LDAN 40H
          02D2     0040
0639      02D3     003A             OUT 2
0640      02D4     00FD             LDA 5
0641      02D5     003D             OUTX 5
0642      02D6     00B8             MOVN PF,0
          02D7     0018
0643      02D8     00F0             LDAI 0
0644      02D9     003C             OUTX 4
0645      02DA     0023             LDAN 4
          02DB     0004
0646      02DC     003E             OUTX 6
0647      02DD     0054             CALL STROBE
          02DE     00F4
0648      02DF     0018             INC 0
0649      02E0     00F0             LDAI 0
0650      02E1     0047             SWAP
0651      02E2     003C             OUTX 4
0652      02E3     0023             LDAN 2
          02E4     0002
0653      02E5     003E             OUTX 6
0654      02E6     0054             CALL STROBE
          02E7     00F4
```

```
0655   02E8   00F0            LDAI 0
0656   02E9   003C            OUTX 4
0657   02EA   0023            LDAN 1
       02EB   0001
0658   02EC   003E            OUTX 6
0659   02ED   0054            CALL STROBE
       02EE   00F4
0660   02EF   0027            CLA
0661   02F0   003C            OUTX 4
0662   02F1   003D            OUTX 5
0663   02F2   003E            OUTX 6
0664   02F3   0093            RETR
0665  *
0666  *          SUBROUTINE STROBE
0667  *
0668   02F4   0023  STROBE    LDAN 40
       02F5   0028
0669   02F6   003A            OUT 2
0670   02F7   003F            OUTX 7
0671   02F8   0027            CLA
0672   02F9   003F            OUTX 7
0673   02FA   0023            LDAN 40H
       02FB   0040
0674   02FC   003A            OUT 2
0675   02FD   0093            RETR
0676  *
0677  *          SUBROUTINE THUMBDIAL
0678  *
0679   02FE   0023  THUMBDIL  LDAN 50H
       02FF   0050
0680   0300   003A            OUT 2
0681   0301   00FF            LDA 7
0682   0302   003C            OUTX 4
0683   0303   000D            INX 5
0684   0304   0000            NOP
0685   0305   0000            NOP
0686   0306   0000            NOP
0687   0307   0086            BF0 TMB1
       0308   000A
0688   0309   0027            CLA
0689   030A   00A8  TMB1      STA 8
0690   030B   001F            INC 7
0691   030C   00FF            LDA 7
0692   030D   003C            OUTX 4
0693   030E   000D            INX 5
0694   030F   0047            SWAP
0695   0310   0048            IOR 8
0696   0311   0037            CMA
0697   0312   00A8            STA 8
0698   0313   001F            INC 7
0699   0314   00FF            LDA 7
```

```
0700    0315    003C              OUTX 4
0701    0316    000D              INX 5
0702    0317    0037              CMA
0703    0318    0053              ANDN 15
        0319    000F
0704    031A    00AE              STA 6
0705    031B    0093              RETR
0706  ************
0707  *
0708  *         DATA
0709  *
0710  ************
0711                  0018  PF    EQU 30B
0712                  00FF  FFH   EQU 377B
0713                  00AA  AAH   EQU 252B
0714                  00F0  F0H   EQU 360B
0715  *
0716                              END
```

APPENDIX G

BUREAU 8748 CROSS ASSEMBLER MNEMONICS

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DEFINITION OF TERMS FOR INSTRUCTION SET SUMMARY

A	The accumulator register
r	Working register, can be a number from 0 to 7
XXX	Three-bit binary code for a working register
i	Indexing register, can be only 0 or 1. Can also refer to the binary code
#DATA	A number from 0 to 255. If the number is octal, it must be followed with a "B" (10B). If the number is hex, it must be followed with an "H" (10H).
#	Same as #DATA
n	Same as #DATA
( )	Do not use the expression in parentheses as the data but rather as the address of the data
C	The carry bit
P	Input/Output port (8 bits wide)
p	Input/Ouput port number, local port, can be a number from 0 to 2
Q	Input/Output port (4 bits wide)
q	Input/output port number, external port, can be a number from 4 to 7 (Note: Data moves are to and from bits 0 through 3 of A. On input from a port, bits 4 through 7 of A are cleared.)
YY	Two-bit binary code for I/O port number. The following codes are used: BUS - 00 Local port 1 - 01 Local port 2 - 10 External port 4 - 00 External port 5 - 01 External port 6 - 10 External port 7 - 11
BUS	The 8-bit bidirectional port which provides an expansion memory interface
a	An address label
A_0-A_{10}	Address bits used by program counter (11 bits). A_0 is least significant bit
PSW	Program status word
T	Timer/Counter
∩	Logical AND operator
∪	Logical OR operator
⊎	Logical exclusive OR operator

INSTRUCTION SET SUMMARY

Intel Mnemonic	Description	Op. Code	Bureau 8748 Cross Assembler	Inst. Type
ADD A, Rr	$A \leftarrow A + r$	01101XXX	ADD r	ACCUMULATOR
ADD A, @Ri	$A \leftarrow A + (i)$	0110000i	ADDI i	
ADD A, #DATA	$A \leftarrow A + \#$	[1]00000011	ADDN n	
ADDC A, Rr	$A \leftarrow A + r + C$	01111XXX	ADC r	
ADDC A, @Ri	$A \leftarrow A + (i) + C$	0111000i	ADCI i	
ADDC A, #DATA	$A \leftarrow A + \# + C$	[1]00010011	ADCN n	
ANL A, Rr	$A \leftarrow A \cap r$	01011XXX	AND r	
ANL A, @Ri	$A \leftarrow A \cap (i)$	0101000i	ANDI i	
ANL A, #DATA	$A \leftarrow A \cap \#$	[1]01010011	ANDN n	
ORL A, Rr	$A \leftarrow A \cup r$	01001XXX	IOR r	
ORL A, @Ri	$A \leftarrow A \cup (i)$	0100000i	IORI i	
ORL A, #DATA	$A \leftarrow A \cup \#$	[1]01000011	IORN n	
XRL A, Rr	$A \leftarrow A \uplus r$	11011XXX	XOR r	
XRL R, @Ri	$A \leftarrow A \uplus (i)$	1101000i	XORI i	
XRL A, #DATA	$A \leftarrow A \uplus \#$	[1]11010011	XORN n	
INC A	$A \leftarrow A + 1$	00010111	INA	
DEC A	$A \leftarrow A - 1$	00000111	DCA	
CLR A	$A \leftarrow 0$	00100111	CLA	
CPL A	$A \leftarrow \overline{A}$	00110111	CMA	
DA A	Decimal adjust	01010111	DAA	
SWAP A	Swap nibbles in A	01000111	SWAP	
RL A	Rotate A left	11100111	RL	
RLC A	Rotate A left with C	11110111	RLC	
RR A	Rotate A right	01110111	RR	
RRC A	Rotate A right with C	01100111	RRC	

INSTRUCTION SET SUMMARY (Continued)

Intel Mnemonic	Description	Op. Code	Bureau 8748 Cross Assembler	Inst. Type
IN A, Pp	A ← P	000010YY	IN p	INPUT/OUTPUT
OUTL Pp, A	P ← A	001110YY	OUT p	
ANL Pp, #DATA	P ← P ∩ #	[1]100110YY	ANDP n, p	
ORL Pp, #DATA	P ← P ∪ #	[1]100010YY	IORP n, p	
INS A, BUS	A ← BUS	00001000	LDAB	
OUTL BUS, A	BUS ← A	00000010	STAB	
ANL BUS, #DATA	BUS ← BUS ∩ #	[1]10011000	ANDB n	
ORL BUS, #DATA	BUS ← BUS ∪ #	[1]10001000	IORB n	
MOVD A, Pq	A ← Q	000011YY	INX q	
MOVD Pq, A	Q ← A	001111YY	OUTX q	
ANLD Pq, A	Q ← Q ∩ A	100111YY	ANDX q	
ORLD Pq, A	Q ← Q ∪ A	100011YY	IORX q	
INC Rr	r ← r + 1	00011XXX	INC r	REGISTERS
INC @Ri	(i) ← (i) + 1	0001000i	INCI i	
DEC Rr	r ← r − 1	11001XXX	DEC r	

INSTRUCTION SET SUMMARY (Continued)

Intel Mnemonic	Description	Op. Code	Bureau 8748 Cross Assembler	Inst. Type
JMP a	JUMP	[2]$A_{10}A_9A_8$00100	JMP a	BRANCH
JMPP @A	PC ← (A)	10110011	JMPA	
DJNZ Rr, a	r ← r− 1 BRANCH if R ≠ 0	[2]11101XXX	DBNZ a, r	
JC a	BRANCH if C = 1	[2]11110110	BCS a	
JNC a	BRANCH if C = 0	[2]11100110	BCC a	
JZ a	BRANCH if A = 0	[2]11000110	BZ a	
JNZ a	BRANCH if A ≠ 0	[2]10010110	BNZ a	
JTO a	BRANCH if T0 = 1	[2]00110110	BTOH a	
JNTO a	BRANCH if TO = 0	[2]00100110	BTOL a	
JT1 a	BRANCH if T1 = 1	[2]01010110	BTIH a	
JNTI a	BRANCH if T1 = 0	[2]01000110	BTIL a	
JFO a	BRANCH if FLAG 0 = 1	[2]10110110	BFO a	
JF1 a	BRANCH if FLAG 1 = 1	[2]01110110	BF1 a	
JTF a	BRANCH if TIMER FLAG = 1	[2]00010110	BTS a	
JNI a	BRANCH if $\overline{INT}$ = 0	[2]10000110	BIL a	
JBb a	BRANCH if A, BIT 'b' = 1	[3]$b_2b_1b_0$10010	BBS a, b	
CALL a	STACK AND JUMP	[2]$A_{10}A_9A_8$10100	CALL a	SUBROUTINE
RET	RETURN	10000011	RET	
RETR	RETURN AND RESTORE	10010011	RETR	
CLR C	C ← 0	10010111	CLC	FLAGS
CPL C	C ← $\overline{C}$	10100111	CMC	
CLR FO	FO ← 0	10000101	CLFO	
CPL FO	FO ← $\overline{FO}$	10010101	CMFO	
CLR F1	F1 ← 0	10100101	CLF1	
CPL F1	F1 ← $\overline{F1}$	10110101	CMF1	

INSTRUCTION SET SUMMARY (Continued)

Intel Mnemonic	Description	Op. Code	Bureau 8748 Cross Assembler	Inst. Type
MOV A, Rr	A ← r	11111XXX	LDA r	DATA MOVES
MOV A, @Ri	A ← (i)	1111000i	LDAI i	
MOV A, #DATA	A ← #	[1]00100011	LDAN n	
MOV Rr, A	r ← A	10101XXX	STA r	
MOV @Ri, A	(i) ← A	1010000i	STAI i	
MOV Rr, #DATA	r ← #	[1]10111XXX	MOVN n, r	
MOV @Ri, #DATA	(i) ← #	[1]1011000i	MOVNI n, i	
MOV A, PSW	A ← PSW	11000111	LDAS	
MOV PSW, A	PSW ← A	11010111	STAS	
XCH A, Rr	A ⇆ r	00101XXX	XCH r	
XCH A, @Ri	A ⇆ (i)	0010000i	XCHI i	
XCHD A, @Ri	A (Bits 0-3) ⇆ (i) (Bits 0-3)	0011000i	XCHD i	
MOVX A, @Ri	[3]A ← (i)	1000000i	LDXI i	
MOVX @Ri, A	[3](i) ← A	1001000i	STXI i	
MOVP A @A	$A \leftarrow \{A_{10} - A_8 = PC\} \{A_7 - A_0 = A\}$	10100011	LDAA	
MOVP3 A, @A	$A \leftarrow \{A_{10} - A_8 = 011\} \{A_7 - A_0 = A\}$	11100011	LDA3	
MOV A, T	A ← T	01000010	LDAT	TIMER/COUNTER
MOV T, A	T ← A	01100010	STAT	
STRT T	START TIMER	01010101	TIME	
STRT CNT	START EVENT-COUNTER	01000101	CNT	
STOP TCNT	STOP TIMER/EVENT-COUNTER	01100101	STOP	
EN TCNTI	ENABLE TIMER/COUNTER INT	00100101	ENTC	
DIS TCNTI	DISABLE TIMER/COUNTER INT	00110101	DITC	

INSTRUCTION SET SUMMARY (Continued)

Intel Mnemonic	Description	Op. Code	Bureau 8748 Cross Assembler	Inst. Type
EN I	ENABLE INTERRUPT (EXT.)	00000101	ENI	CONTROL
DIS I	DISABLE INTERRUPT (EXT.)	00010101	DII	
SEL RBO	SELECT REGISTER BANK O	11000101	SRO	
SEL RB1	SELECT REGISTER BANK 1	11010101	SR1	
SEL MBO	SELECT MEMORY BANK 0	11100101	SMO	
SEL MB1	SELECT MEMORY BANK 1	11110101	SM1	
ENTO CLK	ENABLE CLOCK OUTPUT	01110101	ENCO	
NOP	NO OPERATION	00000000	NOP	

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[1] Two-byte instructions with second byte containing the data.

[2] Two-byte instructions with second byte containing A_0-A_7 of the address for transfer of control.

[3] These instructions move data to and from external data memory. All other indirect operations are associated with the 8748 on chip RAM.

A free pamphlet is available from the Bureau of Reclamation entitled, "Publications for Sale". It describes some of the technical publications currently available, their cost, and how to order them. The pamphlet can be obtained upon request to the Bureau of Reclamation, Engineering and Research Center, PO Box 25007, Denver Federal Center, Bldg. 67, Denver, CO 80225, Attn: D-922.